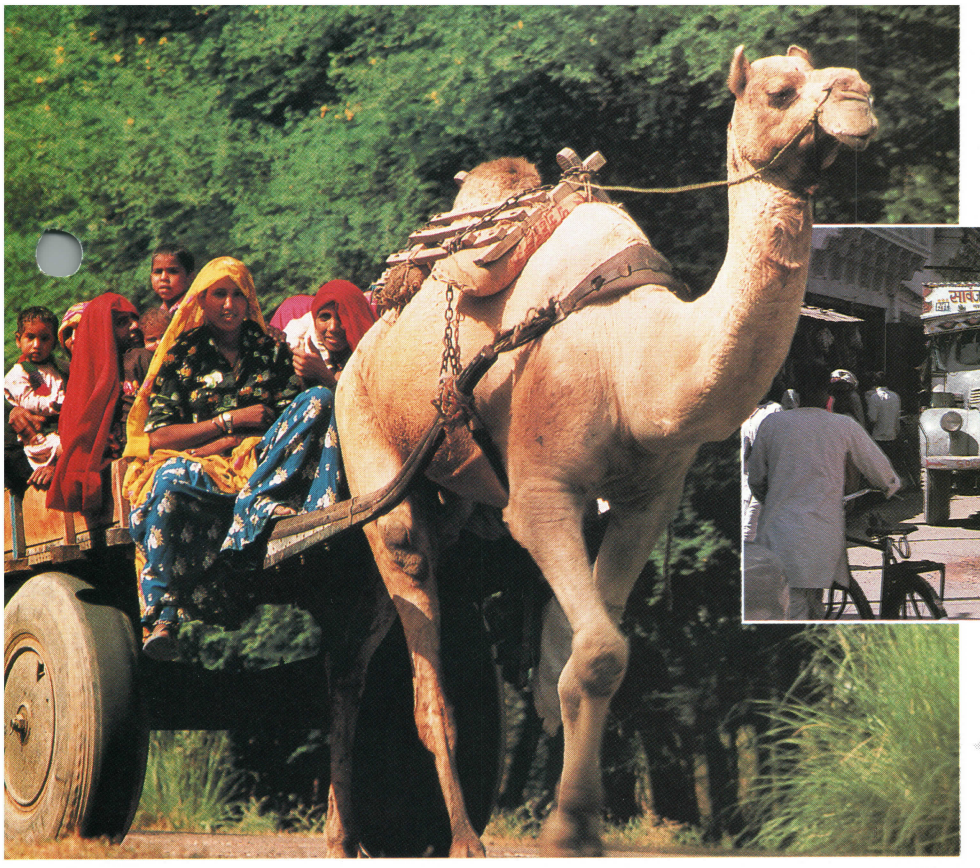


The camel *and the bullock have yet to be overtaken by motorized transport in countries such as India. But although four feet are more economical than fossil fuel, both passenger and animal take advantage of modern technology for a smoother ride, with the aid of pneumatic tyres.*

Hutchison Library Tony Stone Photo Library, London

BRUTE STRENGTH

ANIMALS ARE STILL AN important source of motive power for most of the world's peoples. They carry people and goods, and draw vehicles and ploughs. Only slowly are they giving way to tractors, vans and motorbikes.

Motor vehicles are becoming ever cheaper and more convenient for people in the poorer countries. Tractors and small trucks can enormously increase the productivity and income of farmers and traders. However, animals are cheaper to buy and maintain. They do not need to be repaired with expensive spare parts that often have to be imported, and they reproduce themselves to increase their numbers.

Under the yoke

The tasks that were performed in the West by horses, before the petrol engine took over, are carried out in India, China and other parts of Asia by the hump-backed zebu and its close relative, the water buffalo.

The buffalo's hump makes it easy to yoke the animal with a pole that passes in front of the hump and is prevented from slipping sideways by vertical side-pieces. Since the horse lacks a hump, the first harnesses for horses had a breast-band, but this constricted the animal's windpipe when it tried to pull a heavy load. The use of the horse as a draught animal (that is, for pulling) became widespread in Europe only when the padded horse-collar was invented as late as the 10th century AD.

Owners of oxen and buffalo in Third World countries often take advantage of the arrival of motor vehicles. They shoe their beasts with cut-down car tyres and even equip their carts with car wheels and axles.

Oxen were almost as important in the West until quite recent times. The covered wagons of pioneers in America, Australia and South Africa were more often drawn by oxen than by horses. Oxen are still important in agriculture in many Mediterranean countries and in Eastern Europe.

In India and Burma, elephants have been domesticated for carrying goods and passengers. A large, mature elephant can carry a load of as much as one third of a tonne. Elephants are also important in hauling logs in the dense forests.

Elephants were once used in warfare, both in Asia and in North Africa. One of them could carry a couple of soldiers and their weapons in what amounted to a tiny fortress.

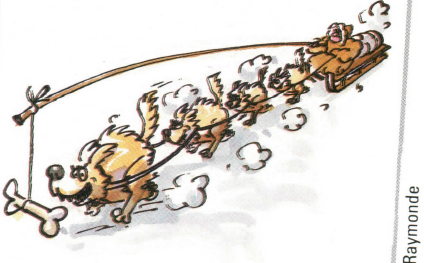
Dune buddies

Perhaps the most impressive beasts of burden are camels. They are marvellously adapted to the dry regions in which they live. Ridden occasionally and also used for carrying goods, they may be used for hauling carts. A Bactrian (two-humped) camel can carry as much as 270 kg, while a dromedary (one-

Just amazing!

DOG GONE

IN 1987, SUSAN BUTCHER'S DOG TEAM SET A RECORD FOR THE IDITAROD TRAIL DOG SLED RACE IN ALASKA BY COVERING THE DISTANCE OF 1,688 KM – OR THE EQUIVALENT OF 40 MARATHON COURSES – IN 11 DAYS 2 HOURS AND 5 MINUTES.



Paul Raymonde

humped) can carry loads up to 405 kg. By comparison, a pack horse can carry about 125 kg. The dromedary lives in India, the Middle East and North Africa. It is longer-legged than its two-humped cousin, standing about 2 metres high at the shoulder. The dromedary has a lighter-coloured, shorter coat than the shaggy brown Bactrian, which lives in central Asia, northern China and Mongolia.

Handy in the Andes

The camels of today are descended from ancestors that flourished in North America millions of years ago. Other descendants of these extinct animals are the domesticated llamas and alpacas and the wild vicunas and guanacos of the South American Andes. Llamas were used as pack animals rather than for drawing vehicles, which were not used in the Andes before modern times. They can carry only about 45–60 kg.

Llamas are nimble and sure-footed. So too are sheep and goats, both of which are used for carrying light loads at great altitudes.

The donkey, or ass, was domesticated around 3000 BC in the Nile Valley, where it was used as a pack animal. Wild asses are creatures of arid regions, so their domesticated relatives need little food.

Farther to the east, in Central Asia, another type of wild donkey, called the onager, was domesticated by the Sumerians and used to pull their war chariots, until it was replaced by the stronger horse.

Tony Stone Photo Library. London

Sullivan & Rogers/Bruce Coleman Ltd

Dallying llamas *are goaded past railway tracks. Adapted to the high altitude of the Andes, they may make more reliable carriers than trains.*

Bowed down *under its load, a donkey carries empty soft drinks bottles in Morocco. Unlike a lorry that is usually used for this purpose, the donkey can negotiate the narrow streets without getting stuck.*

Elephants *are the traditional beast of burden in Asia. Mature animals can carry loads up to a third of a tonne.*

Tony Stone Worldwide

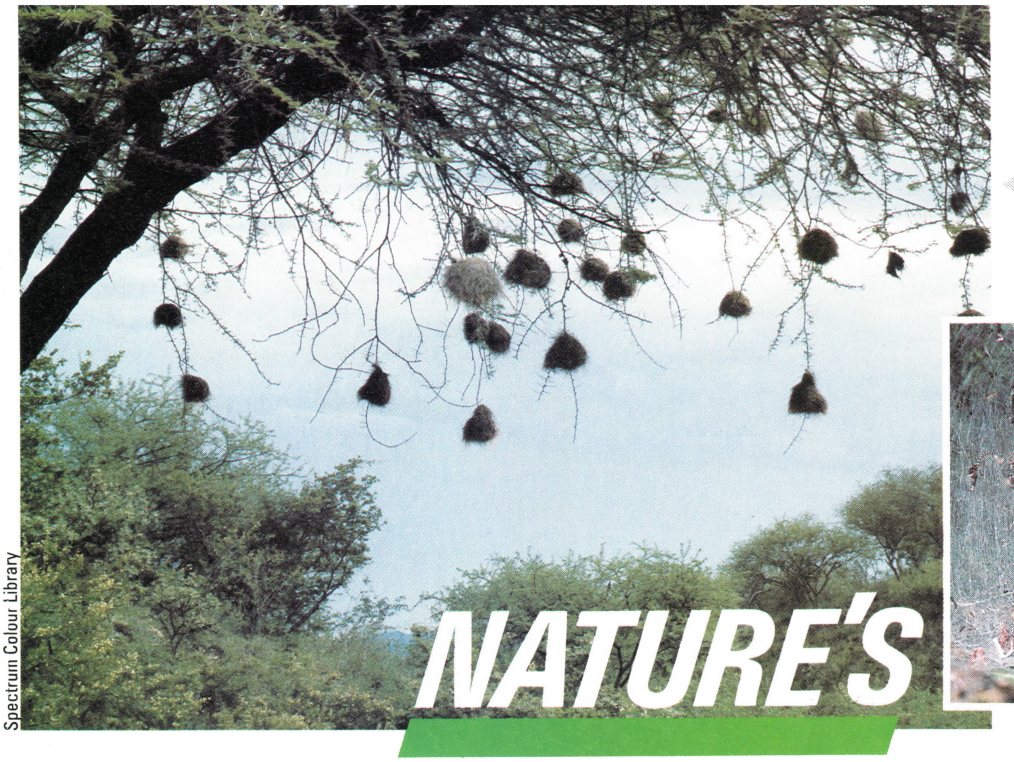
SHIPS OF THE DESERT

The camel's ability to journey across arid wastes without food or water, long after most other animals (including human beings) would have died, is legendary. Their bodies are adapted in many ways to the special needs of their desert homes, where food is scarce and oases few and far between.

Unlike other mammals, which sweat during the day to keep cool, camels conserve water by allowing their body temperature to rise throughout the day to as much as 11–14.5°C. They begin to sweat only when the external temperature rises above 40°C.

Their urine is very concentrated, which also helps to conserve water, and their thick coat helps to keep heat out during the day and in at night. The camel's body fat is not distributed around the body – this would hinder the loss of body heat during the day. Instead, it is concentrated in the hump, or humps, which are stores of energy. When camels go without food for a long time, their humps shrink as the fat is used up. If not working, they can last on this fat for up to ten months.

When a camel gets the chance to drink, it can consume over 100 litres of water – a quarter of its own body weight – at one time. Almost any other animal that did the same would die.



Spectrum Colour Library

Nest building *or weaving webs comes instinctively to animals. Weaver birds make nests of grass intertwined into a framework of knotted grass and twigs, which they hang from tree branches. Some species of spiders spin intricate webs from sticky thread (below) to catch prey.*

Natural Science Photos

NATURE'S ARCHITECTS

- TAILOR-MADE HOMES
- NATURAL MATERIALS
- DEEP-SEA TUNNELS

BREATHTAKING HOMES – either short-lived nests in which to raise young, or long-lived 'cities' in which to shelter a community – are often built by animals. These structures are often complex and ingenious and, sometimes, massive in scale.

Often the function of a structure built by an animal is to provide a controlled environment. For example, the male three-spined stickleback digs a channel in the bed of a stream, then fills this up with scraps of vegetation. It bonds this together with a 'cement' it secretes, then burrows through the mass. The female lays her eggs in this tunnel. The tunnel not only makes it difficult for other fish to get at the eggs and eat them, it also allows the male stickleback to set up a stream of water over the eggs by fanning them with its fins and thus providing them with oxygen.

Air conditioning

The elaborate hives of the social insects, such as honeybees, termites and many species of ants, provide a controlled climate as well as serving many other functions. The moulds built by termites in Africa and South America are made of mud and plant material bonded with saliva and excreta and can rise up several metres.

These mounds often have tall 'spires' that function as chimneys, creating up-currents of air through the nest. The air from the nest below rises up to the main chimney and, through it, to the side chimneys, whose walls are thinner. Through them, the carbon dioxide from inside is exchanged for oxygen from the outside. Thus, air circulates constantly, helping to keep the temperature, humidity and oxygen concentration at the correct levels. There is more carbon dioxide in the nest's atmosphere than in the air outside – enough to make a person lose consciousness if they had to breathe it.

Building materials

Animals use an enormous variety of materials in building. The paper wasp uses, as its name implies, a paper-like material that it produces by chewing wood. Weaver ants 'sew' leaves together: the thread, silk-spun by the ant larva, is passed back and forth from leaf to leaf, gripped in the jaws of an adult ant.

Honey bees make their combs from wax that is formed in flakes on the underside of the worker bees' abdomens. Weaver birds build their

The honeycombed pattern *of a wasp's nest is such a strong, yet light, structure that it is copied in the design of some aircraft wings.*

Natural Science Photos

large, baglike nests by weaving together twigs and blades of grass. In some ants' nests, soldier ants will even plug holes in the walls with their oversized heads to keep out enemies.

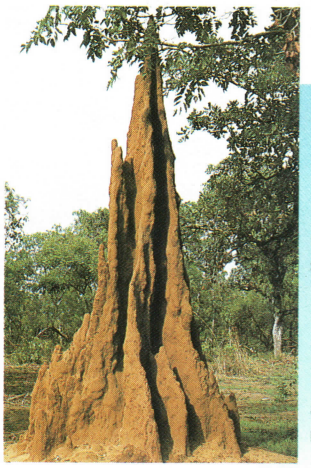
Dam-builders

Perhaps the most spectacular animal constructions are the dams and lodges built by beavers in North America. The beavers' long front teeth grow throughout the animals' lives and are kept to a manageable length by gnawing at the trunks and branches of trees. A beaver can fell a tree a metre thick. It eats the leaves and thin branches, then floats branches down the river to the site where the dam is to be built. The animal carries mud and stones in its forepaws and adds them to the branches to form the dam.

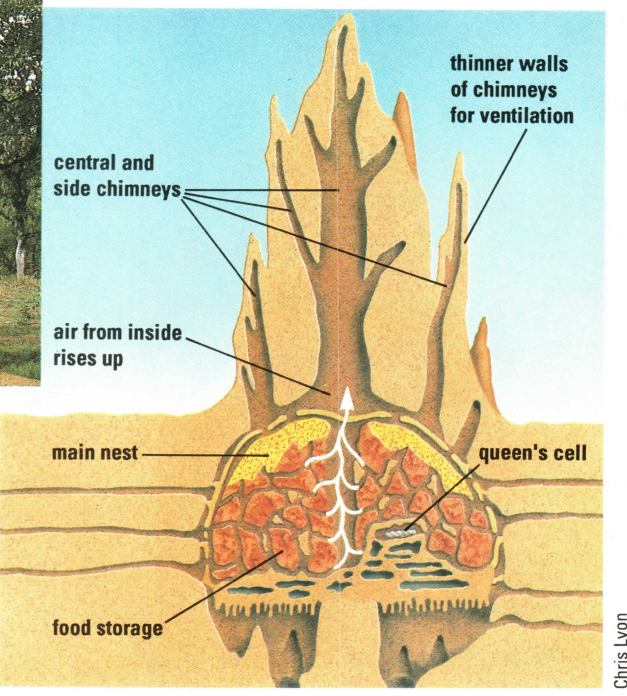
Some distance from the dam, in the lake thus formed, the beavers build a dome-shaped 'lodge' which provides a haven for one or more family groups. The entrances are under water so that they give access to the water even when the surface is frozen over in winter. Beavers can strip the lake shore of all trees to a distance of hundreds of metres. When they have done this, they simply move on to a new site. Eventually, the old site silts up and new vegetation grows on the rich soil created by the beavers' building. In this way, the soil is regenerated in a natural cycle.

Spiders build webs of sticky silk threads to trap small insects. There are many different types of webs, including the broad, flat 'orb' webs of garden spiders, the three-dimensional webs of cobweb spiders and funnel-shaped webs. Not many species of spider, however, make webs.

Half a dozen types of silk may be produced by the spider: one for making webs, one for wrapping prey, another for the sticky droplets on the webs, and so on. Silk is formed as a liquid in the spider's body. If it is to be used in building, it is solidified as it is squeezed out of the spider's body. The thread is highly elastic and immensely strong in relation to its thickness.



Peter Ward/Bruce Coleman Limited



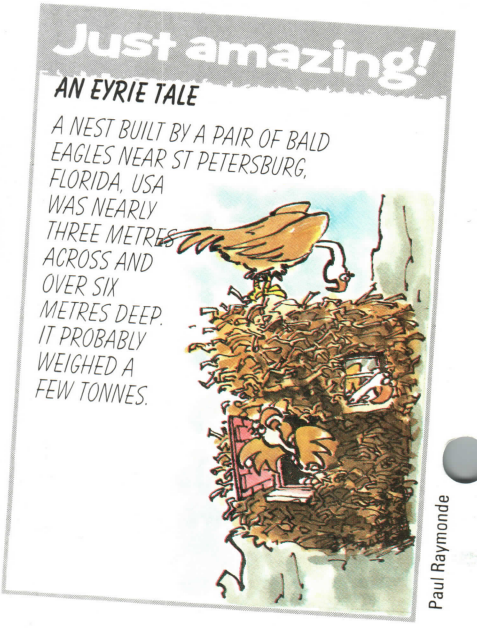
Chris Lyon

Termite towers *are made from mud mixed with the saliva of termites – a mixture that sets as hard as concrete. The tall chimneys provide ventilation for the main nest.*

Jen & Des Bartlett/Bruce Coleman Limited

Beaver dams *are constructed from twigs and stones to create an area of still water so the animals can gain entry to their burrows. With their huge incisors, beavers can fell trees up to one metre in diameter.*

Natural Science Photos



Paul Raymonde

THE DEVELOPING BRAIN

- EMBRYONIC BRAIN
- TWO HEMISPHERES
- BRAIN SIZE

FOSSIL REMAINS SHOW THAT early Man had a much smaller brain than we have today. A close ancestor of modern Man known as Pithecanthropus had a brain weighing around 1 kg. Yet though it was smaller than our own, the brain of Pithecanthropus was bigger than the brain of a chimpanzee, which weighs around 0.4 kg.

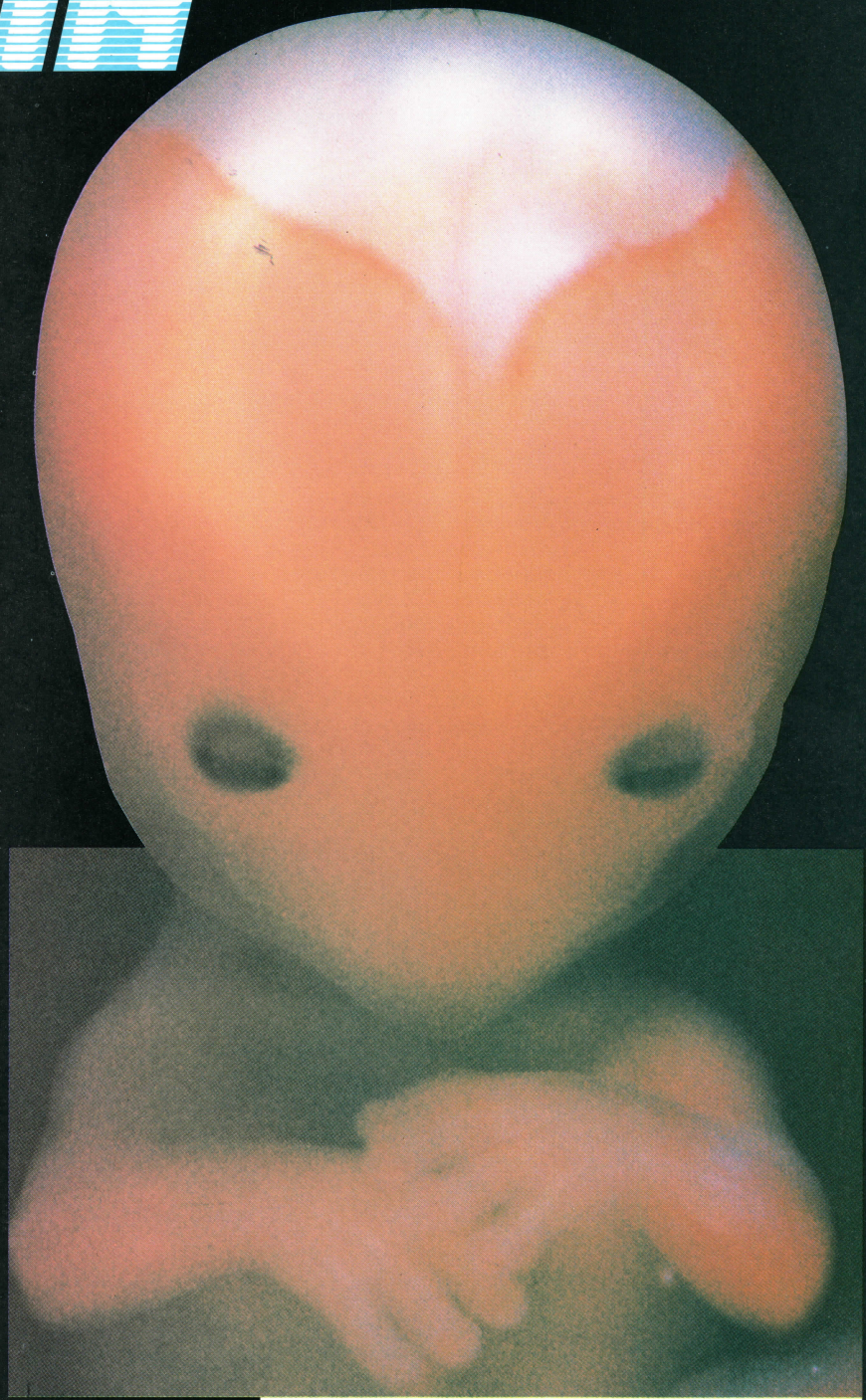
As Man evolved through a series of hominids like Pithecanthropus, the brain increased in size. The relative size of different parts of the brain also changed. Neanderthal man, who lived around 25,000 years ago had a brain about the same size as our own – 1.5 kg. However, the Neanderthal's brain seems to have been concentrated towards the rear of the skull. The brain of the modern human has a much higher proportion of front brain or forebrain, which makes us much better at intellectual and creative work than early Man.

The brain starts developing as soon as the human embryo develops, although at this early stage, brain cells are not noticeably different from other developing cells. Irreversible cell differences do not occur until about 20 days after conception. At this stage, various collections of cells start to specialize in the control of specific functions of the body.

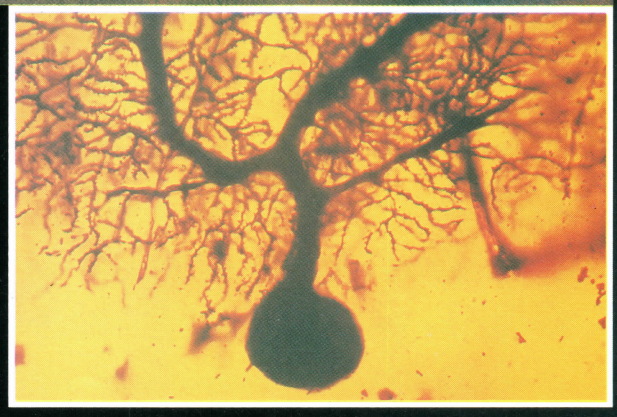
Taking shape

The most important of these collections or groups of cells is the hollow cylinder which forms the embryonic brain and spinal cord. As cell multiplication continues, the basic neurons or nerve cords take shape. A little later, the brainstem and spinal cord neurons begin to send out axons connecting the nerves to the muscles.

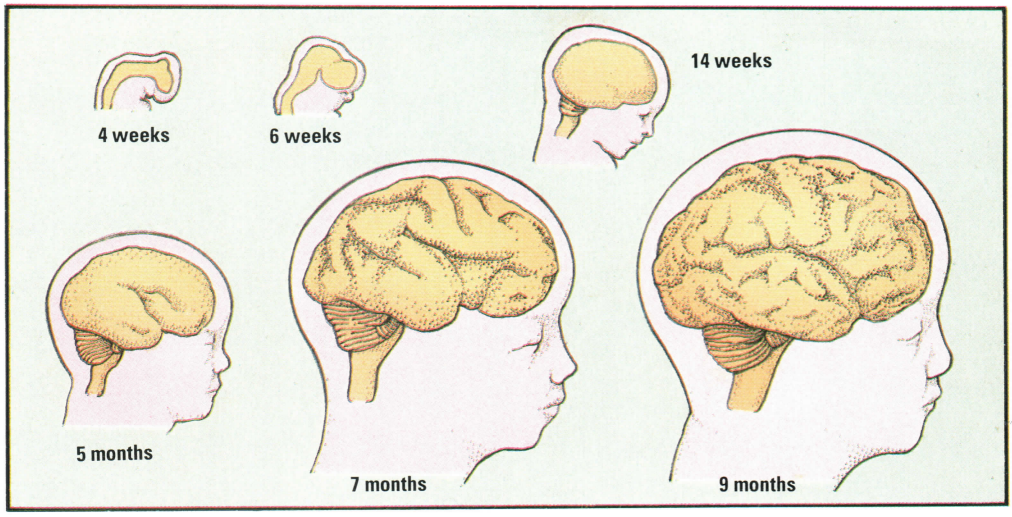
This process is swiftly followed by the growth of sensory cells, which begin to take in impressions from the world outside the embryo. By the end of the first eight weeks of embryonic life, the nervous system is quite well developed. The subsequent 32 weeks up to birth are taken up with more and more



At 12 weeks, *bone has formed around most of the brain to protect it from damage. The head and brain are already further developed than the body.*



Purkinje cells *in the cerebellum (hindbrain) control balance and muscle movement. Branching neurons transmit messages from brain cells.*



Three weeks *after conception, the slab of cells that will form the brain and spinal cord rolls into a tube. By four weeks, the primitive divisions of the brain appear as swellings at the head end of the embryo.*

John Houghton

Spina bifida *is caused by a gap in the cylinder of bone around the spinal cord. It results in varying degrees of handicap – depending on the part of the back affected and severity of damage to nerves.*

elaborate growth. By the time the baby is born, its brain is already a small version (approximately two-thirds the size) of the adult brain.

When the baby arrives in the outside world, the task of forming the inter-connections between brain cells begins. This process is not automatic – it only happens if the baby is stimulated by activities and contact with adults, which start it off on the learning process. Infancy and early childhood are the best times for a child to develop all kinds of mental processes and manual skills.

A well-known example of this learning process is in the teaching of languages. A child taught two, or even three languages by native speakers will grow up capable of speaking each of those languages with the correct accent.

Unfortunately, lack of stimulation during the early months and years of life can lead to quite marked deficiencies in brain growth. Even worse, it appears that this lack of early brain development cannot be put right later in life.

The two hemispheres (halves) of the cerebrum – the back of the brain – control opposite sides of the body. This is illustrated by the way that people with brain injuries behave. If the damage occurs to the right side of the brain, the left side of the body is disabled and the other way round. It works like this because nerve impulses from one side of the brain cross over to the other side, before they leave the brain via a bridge of nerve fibres known as the corpus callosum.

Camilla Jessel

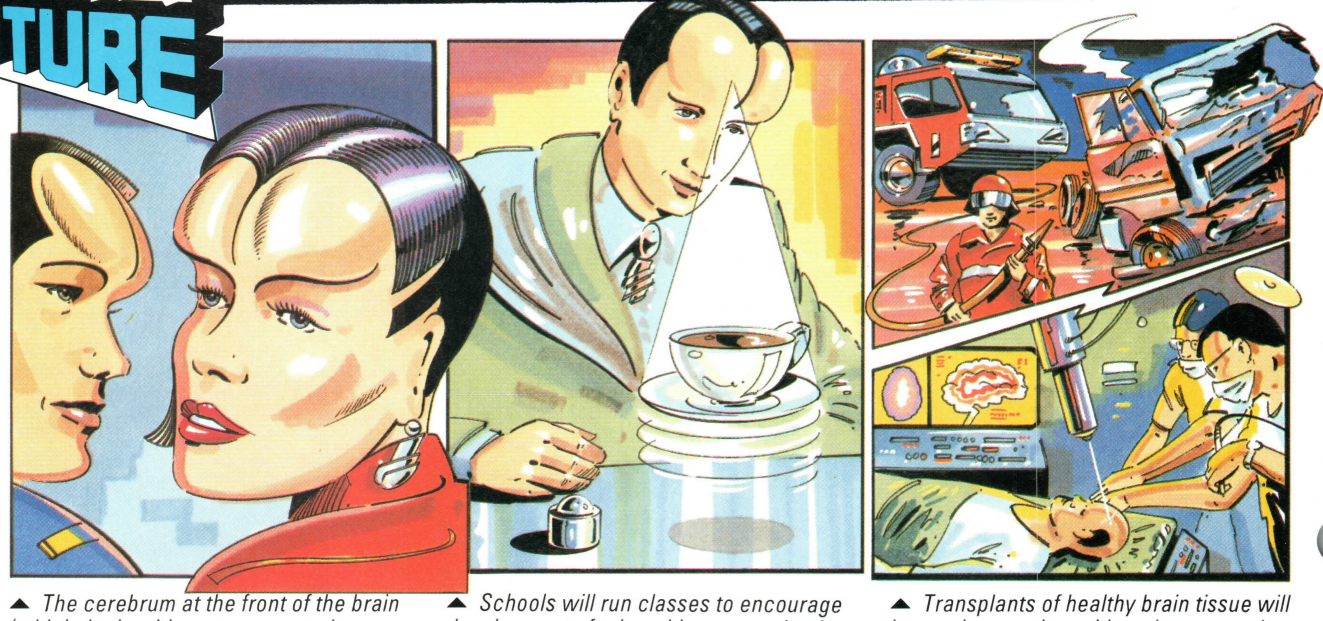
The great divide

It has also been shown that the two halves of the brain are not identical either in the way that they are constructed, or in the work that they do. In most people, for example, the right side of the brain seems to be better at artistic, musical and creative activities, while the left-hand side of the brain is better at dealing with numbers, words, and problem solving.

Recent research has revealed that parts of the brain associated with speech are more developed in the left hand side of the brain as early as 24 weeks after conception. This

INTO THE FUTURE

TOWARDS THE SUPER BRAIN



Joe Lawrence

▲ *The cerebrum at the front of the brain (which deals with memory, consciousness and complicated thinking) will grow larger – so the forehead will also increase in size.*

▲ *Schools will run classes to encourage development of telepathic communication and telekinesis – the ability to move objects around by willpower and thought alone.*

▲ *Transplants of healthy brain tissue will be used to repair accident damage and disease. During operations, electrodes will be used to deaden pain.*

indicates that the brain is already developing the ability to acquire a language.

It may be that late development of cells in this region during foetal brain growth can lead to the condition known as dyslexia. People who suffer from this condition can be perfectly intelligent, yet still have severe problems learning to recognize words. This makes it difficult for them to read and write.

Other parts of the brain appear to have the capacity to develop at different rates before birth. This varying rate of development leads to the variety of abilities and talents that is a characteristic of humans.

These differences in development are caused by instructions carried in the genes of each individual that control the development of nervous tissue. External factors also influence the development of the embryo brain because it is very susceptible to influences reaching it through the mother.

Some external factors are under the direct control of the mother; for example, she can decide whether or not to smoke and/or drink alcohol during her pregnancy. Failure to eat a healthy diet may also affect brain development owing to a lack of nutrients. A similar lack of the right nutrients occurs, because of an addiction to the wrong sorts of food, but in many parts of the world it is due to poverty.

Unfortunately, certain viral infections, such as German Measles (Rubella), can also cross the placenta. If this happens early in pregnancy, there is a possibility of mental retardation because the virus causes changes in the fluid that surrounds the brain.

It is recommended that women who intend to have children are immunized against Rubella. Pregnant mothers normally have a blood test to check their blood type. If a mother is Rhesus negative, in a second pregnancy and with a Rhesus positive foetus, her blood could form antibodies that would attack the baby's red blood cells. This could cause the child to be still-born, or to die at birth due to severe anemia.

STUNTED GROWTH

Experiments conducted on rhesus monkeys have shown that in infants brought up in complete isolation, the thalamus – the part of the brain that registers pleasant emotions – is abnormally small.

If, however, the young monkey is given an artificial 'mother' covered in a soft, furry cloth to which it could cling for comfort, then the thalamus develops normally.

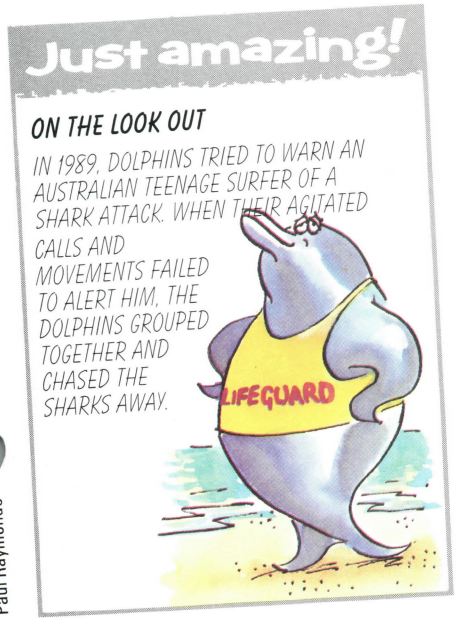
Martin Rogers/Colorific!

BRAINY CREATURES

Dolphins, porpoises and some whales are believed to be the brainiest of our fellow creatures. These mammals all have quite large, complex brains and intelligent behaviour patterns. Research reveals that such marine mammals make a large number of complicated whistling sounds that appear to be comparable with human communication using speech. They can also learn to identify objects and to tell the difference between them fairly easily.

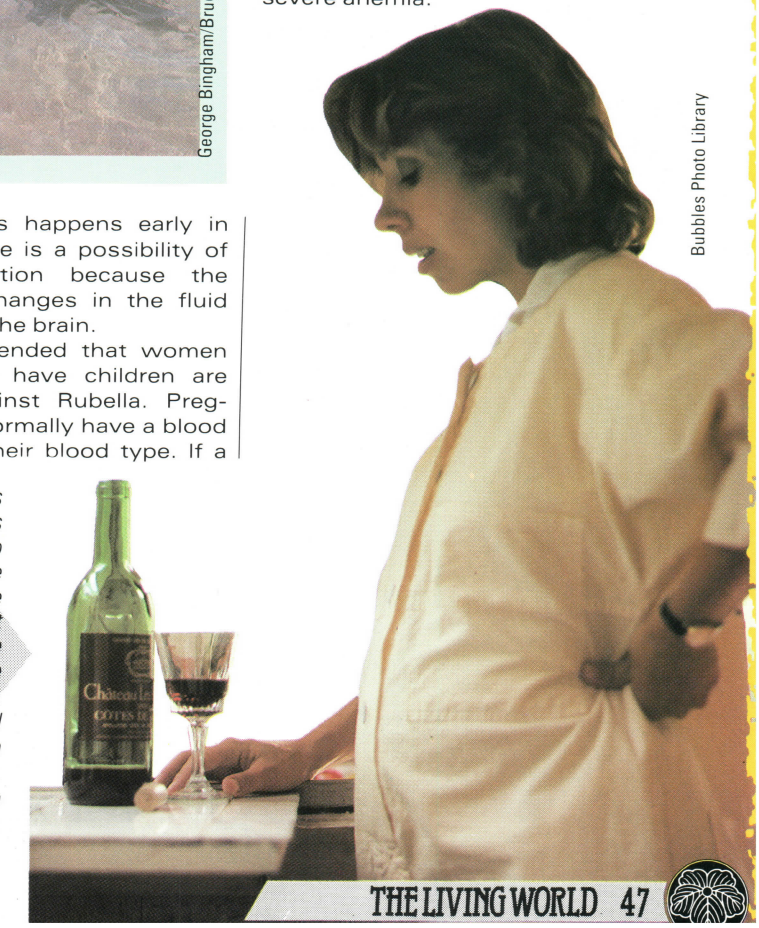
Dolphins learn particularly quickly and have already been used to retrieve objects from the sea bed. They also appear to enjoy contact with humans, whether they are offered food or not. An exciting hope for the future is that we may be able to learn the dolphin 'language' and so break through the communication barrier between humans and animals.

George Bingham/Bruce Coleman Ltd



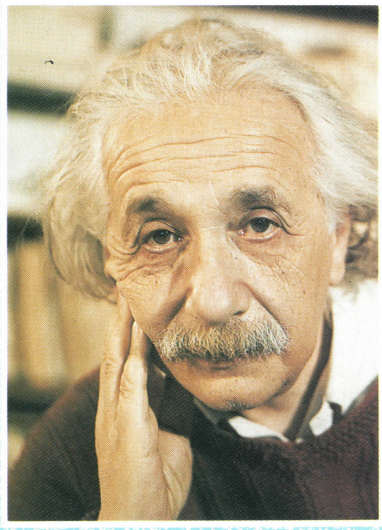
Paul Raymonde

***Alcohol** can pass from the mother's bloodstream into the baby's because its molecules are small enough to get through the membrane separating the two. Once in the foetal bloodstream, it can impair growth, including brain development.*



Bubbles Photo Library

Albert Einstein *1879-1955, physicist. Einstein was a German physicist famous for his Theory of Relativity. This laid the foundations of present-day ideas of how the Universe was formed.*

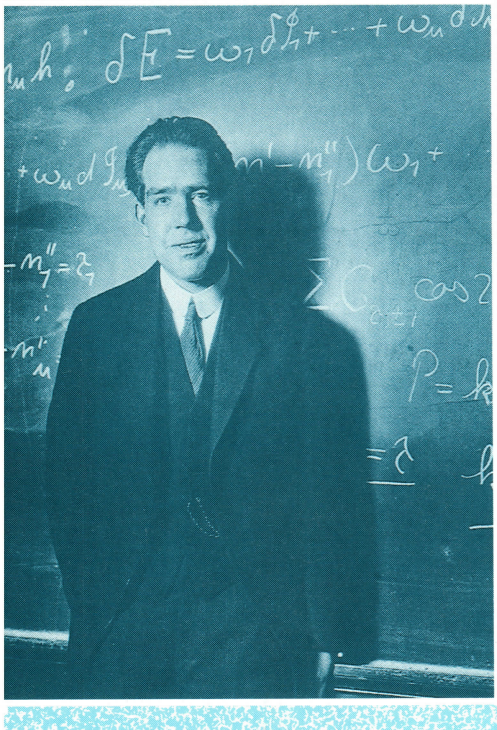


Popperfoto

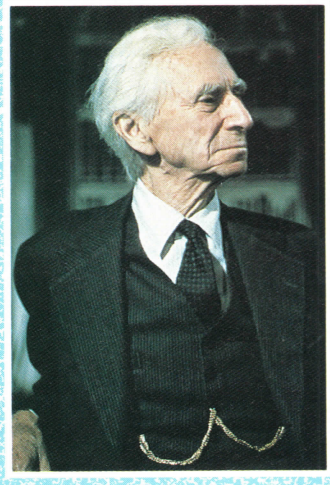
Jean Piaget *1896-1980, psychologist. Piaget was the Swiss founder of the science of developmental psychology. His ideas on the learning process in children have influenced countless teachers.*

Yves de Brahe/Black Star/Colorific!

Neils Bohr *1885-1962. A Danish physicist, Bohr investigated the way atoms behave and the energy they contain. During World War II he worked in America on the atomic bomb project.*



AIP Niels Bohr Library



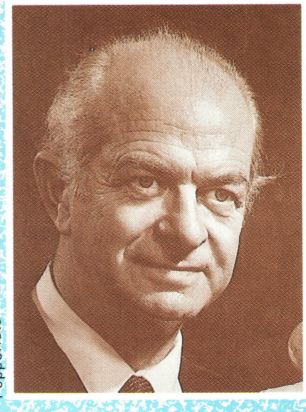
Bertrand Russell *1872-1970, philosopher. Originally a mathematician, Russell's work led him into philosophy. His book* The History of Western Philosophy *is a standard work. He strongly opposed the use of atomic weapons.*

Rex Features

Stephen Hawking *born 1942, physicist. With his best selling book* A Brief History of Time, *Hawking became a scientific 'super-star'. The book deals with the birth and death of the Universe in accordance with the laws of physics.*

Manni Mason's Pictures

Linus Pauling *born 1901, chemist. Pauling was the second person to win two Nobel Prizes. His first was for Chemistry (molecular bonds) in 1954; his second for Peace (banning atmospheric atomic tests) in 1962.*



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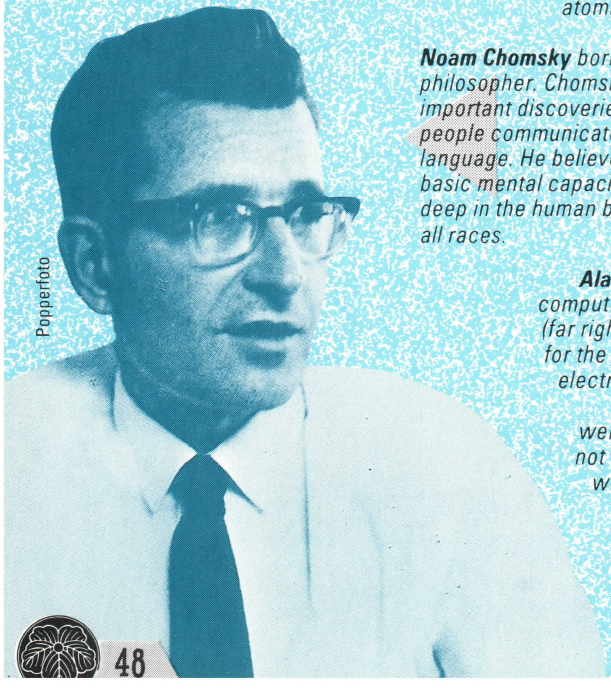
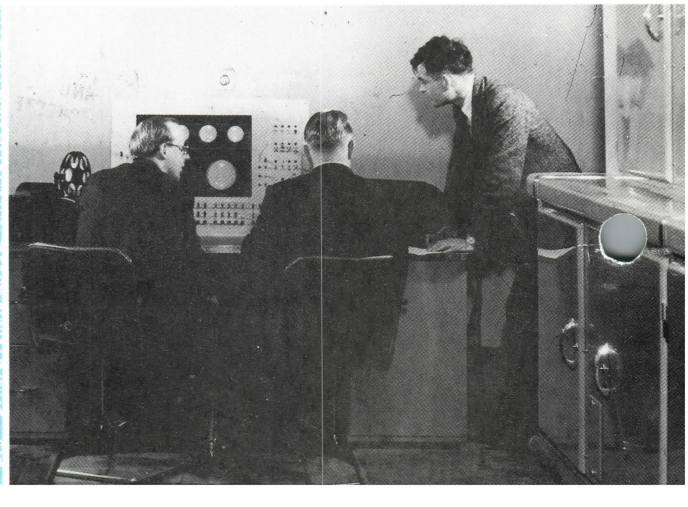
Noam Chomsky *born 1928, linguistic philosopher. Chomsky made important discoveries about how people communicate using language. He believes there is a basic mental capacity for language deep in the human brain that unites all races.*

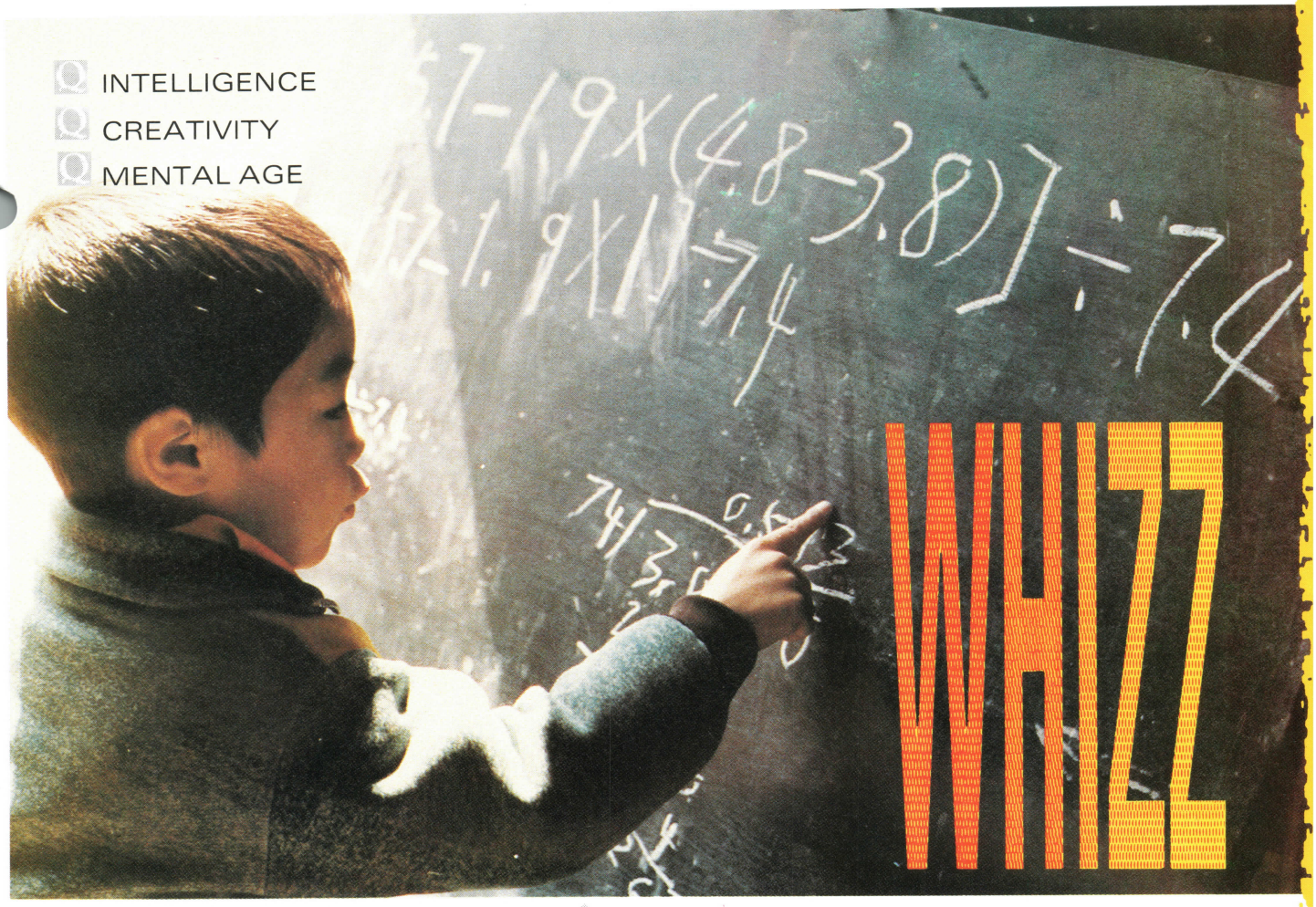


Popperfoto

Alan Turing *1912-1954, computer architect. Turing (far right) was responsible for the basic design of the electronic computer. His original machines were based on valves, not transistors, so they were large and slow.*



- INTELLIGENCE
- CREATIVITY
- MENTAL AGE



Gamma/Frank Spooner Pictures

WHIZZ KIDS

***A four-year old prodigy** demonstrates his remarkable abilities in performing mathematical calculations.*

EVEN THE MOST INTELLIGENT people in the world cannot agree on what intelligence is. Everybody knows roughly what it is, but it is hard to define precisely – and even harder to measure.

Over the years, some psychologists have called intelligence 'the ability to learn'. Others have called it 'the ability to adapt adequately to the environment'. Still others have thought it 'a general tendency towards achievement'.

Types of intelligence

In 1971, psychologist R. B. Cattell suggested that there were two types of intelligence, which he called crystallized and fluid. A child with crystallized intelligence would accurately produce a straightforward answer to a problem, but not attempt to go beyond it. However, a child with fluid intelligence could somehow side-step the expected answer to a problem and produce a creative and unexpected answer.

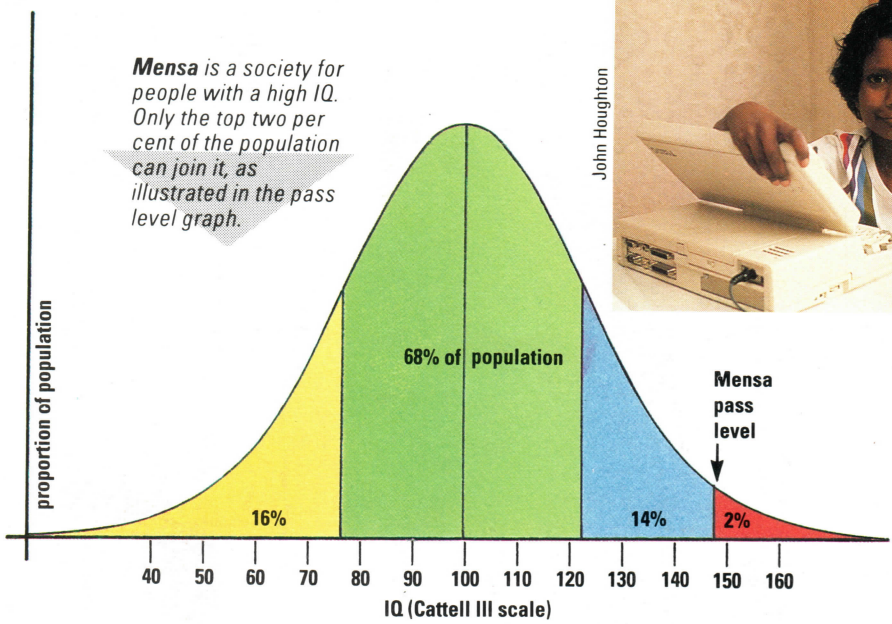
The author and creative thinker, Edward De Bono has described what happened when some children were asked to solve the problem of how to build houses faster. Most of their drawings showed more highly mechanized versions of normal building methods. But one extremely creative child suggested starting with a huge balloon that had an attractive wallpaper pattern printed all over the inside. After inflating the balloon and spraying it with concrete, cut-outs would be made for windows and doors.

The French psychologist Alfred Binet devised a series of problems for testing children's intelligence. Binet reasoned that, if the average six-year-old could copy a drawing of a square, but the average five-year-old could not, then this test was a suitable measure of six-year-old intelligence.

From the results of Binet's work developed the concept of mental age. He supposed that a child's

***Babies soon learn** to copy human behaviour. Some can be taught to speak several words within nine months.*

Enrico Ferorelli/Colorific!



***Mensa** is a society for people with a high IQ. Only the top two per cent of the population can join it, as illustrated in the pass level graph.*

Today/Rex Features Ltd

John Houghton

***The youngest** child to pass GCE A-level in mathematics was Ganesh Sittampalam, who was 9 years and 4 months old when he took the exam. At 13, he gained a mathematics degree.*

brain increased in intellectual power year by year. So two children, shown by the tests to have the same intellectual power, had the same mental age – regardless of their actual ages. A 13-year-old whose results matched those of the average 12-year-old was said to be one year retarded, while a 13-year-old whose results matched those of the average 14-year-old was said to be one year advanced.

A person's intellectual capacity, does not go on increasing indefinitely. Somewhere between the ages of 14 and 18, it begins to level out until there is no yearly improvement at all. One year's 'backwardness' at the age of, say, five is far more significant than at the age of 13, since it represents a much greater proportion of the child's life.

Testing IQ

It was later suggested that the ratio of mental age divided by true age was a better measure than the difference between them. This ratio, when multiplied by 100, is called the intelligence quotient, or IQ. A child whose mental and true ages are the same is, by definition, an average child and has an IQ of 100.

Testing by this method has shown marked differences between people of different backgrounds – for example, wealthy and deprived people in the same country. This is one reason why many psychologists do not regard such traditional tests as adequate.

Children from homes where books, toys, records, lively conversation and other stimuli are present often perform better in school discussions. Since most tests are based on a child's skill with words, it is difficult to measure accurately the intelligence of children whose homes do not provide such advantages. Some children who perform poorly in verbal tests can score well in the non-verbal sections.

Conventional tests are useful in assessing a child's potential for future academic work. But they are virtually useless in measuring perseverance or creativity – both important aspects of other types of work and, indeed, of a versatile human being.

Institute for the Achievement of Human Potential, Philadelphia

Gamma/Frank Spooner Pictures

***Young children** can be trained to develop a wide range of skills, including learning from books and swimming (inset above). While some claim that training improves children's intelligence, others believe the children are simply more able to demonstrate their intelligence rather than responding to training.*

Sally & Richard Greenhill

***Mozart and Mendelssohn,** both child prodigies, have inspired many parents to try to develop similar talents in their own children.*

TRADING ON THE FUTURE

International Coffee Organization

ZEFA

Coffee beans *are picked in vast amounts in South America for consumption – and trading – around the world. Coffee is traded on the FOX (Futures Options Exchange) floor by open outcry. Prices are monitored and reported back to clients by the brokers or their representatives (inset above). Coffee options are traded in contracts of 5 tonnes each.*

GROUPS OF PEOPLE YELLING at each other is standard procedure for setting the price of many goods in daily use – commodity futures trading is what the professionals call it.

Commodities are bought and sold in many markets around the world. In London, for instance, there is the London Metal Exchange, which deals in 'hard' commodities – metals such as copper, lead, zinc and nickel. The London FOX (Futures and Options Exchange) deals in 'soft' commodities such as sugar, coffee, cocoa and rubber.

Two of the world's leading commodities exchanges are in Chicago, operated by the Chicago Board of Trade and the Chicago Mercantile Exchange. There are also important commodities exchanges in New York City.

These American exchanges deal in all sorts of hard and soft commodities, including heating oil, live cattle and hogs, pork bellies – and even orange juice.

Trading sessions in commodity exchanges can be lively affairs. The traders in a particular commodity gather in a ring, known as a pit, and shout out whether they are buying or selling, and what their prices and delivery dates are. The deals they make in this 'open outcry' trading are later confirmed by written contract.

Making money

But this style of trading may soon vanish, as electronic trading systems are introduced. The Chicago Mercantile Exchange, for example, has developed a computerized trading system, called Globex, which has operated a 24-hours-a-day worldwide service since June 1992.

Commodity futures trading is a way for merchants to protect themselves from unexpected rises in the cost of the goods they need and for producers of goods to protect themselves from falling prices. But trading on the futures market is a gamble.

The key to futures trading in a commodity lies in the difference between the spot price and the forward price. The spot price is the cost of goods available for immediate delivery; the forward price is the price you pay now for goods that are yet to be delivered.

Hedging your bets

Suppose you were a miller, making flour from wheat. In order to compete with your rivals, you would need to buy your wheat as cheaply as they did – if not cheaper.

Live sheep *are examined by a vet before they are exported from Australia. There is a world-wide market in meat, dealing mostly in frozen carcasses. However, Muslim countries that need to import meat prefer to buy live animals so that they can slaughter them according to their own religious customs.*

Australian Overseas Information Service, London

The Tea Council Ltd

One way to protect yourself against price rises would be to buy some of your wheat – before you actually needed it – on the futures market. For instance, one spring you might hear that the American wheat harvest due later in the year was likely to be low, causing a rise in world wheat prices. So you could buy wheat, to be delivered in September, at a forward price of, say, £100 a tonne.

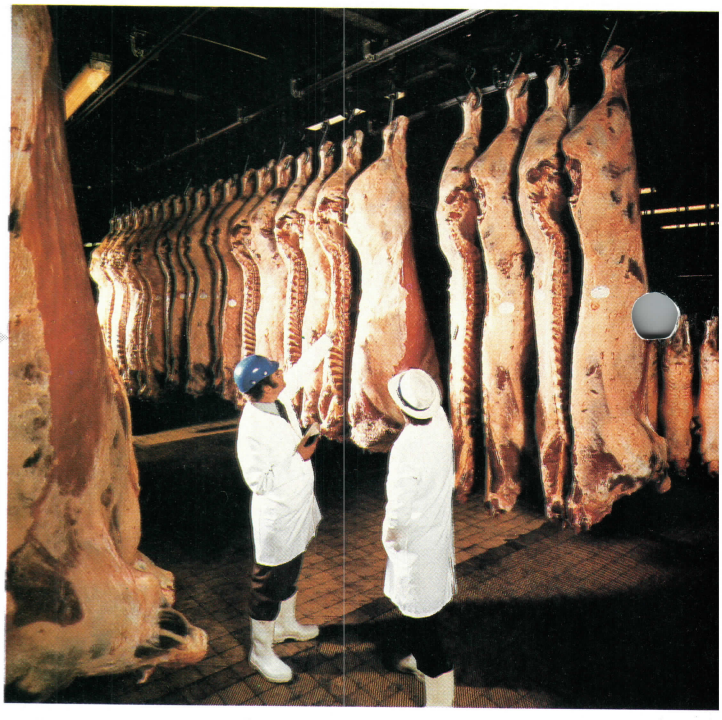
If the American wheat harvest that year did turn out to be low, the spot price in September might have gone up to £125 a tonne. But because you had bought at £100, you'd have saved £25 a tonne on your September wheat. This process of guarding against price rises by buying on the futures market is called hedging.

Because of the possible differences between spot and forward prices, there is big money to be made by people prepared to risk buying futures: if prices rise, they can sell at a profit.

***Tea** is big business – 1,355 cups are drunk per person each year in Britain. Tea is a 'physical commodity'; that is, it is bought and sold, but not traded on the futures market as yet.*

***Meat** can be bought and sold – several times over – on the futures market, without buyer or seller ever seeing it.*

***A golden harvest** of wheat spells good fortune for the farmer, but he can hedge his bets against a poor crop by speculating on the futures prices.*



Meat and Livestock Commission

Just amazing!

DROOPING PRICES

FUTURES MARKETS GO A LONG WAY BACK IN HISTORY. SPECULATION IN TULIP BULB FUTURES SPARKED A STOCK MARKET CRASH IN AMSTERDAM IN THE 17TH CENTURY.

Paul Raymonde

Ivaldi/Jerrican

Speculating

If you were a speculator buying September wheat in spring at £100 a tonne, then selling it in September at £125 a tonne, you would be making a profit of £25 a tonne (less commission). You would not even have to take delivery of the order. Of course, if the spot price of wheat in September turned out to be only £90 a tonne, you would lose £10 a tonne, plus any commission paid on the deal.

Futures contracts can also be bought and sold many times before the goods are due for delivery. Their prices can both rise and fall before that date.

OPEN YOUR EYES AND LET IN light. The energy that enters activates an extremely sensitive and complicated system – a system that enables us to perceive the world around us visually.

The eye acts somewhat like a television camera. It has a lens at the front that can focus the light from near or distant objects by changing its shape: the fatter the lens, the closer the object; the thinner the lens, the further the object.

The iris controls the amount of light entering it by dilating or contracting, rather like the lens in a camera. The aim is to get the image of the outside world in focus and at the right level of brightness on the area at the back of the eye called the retina.

Rods and cones

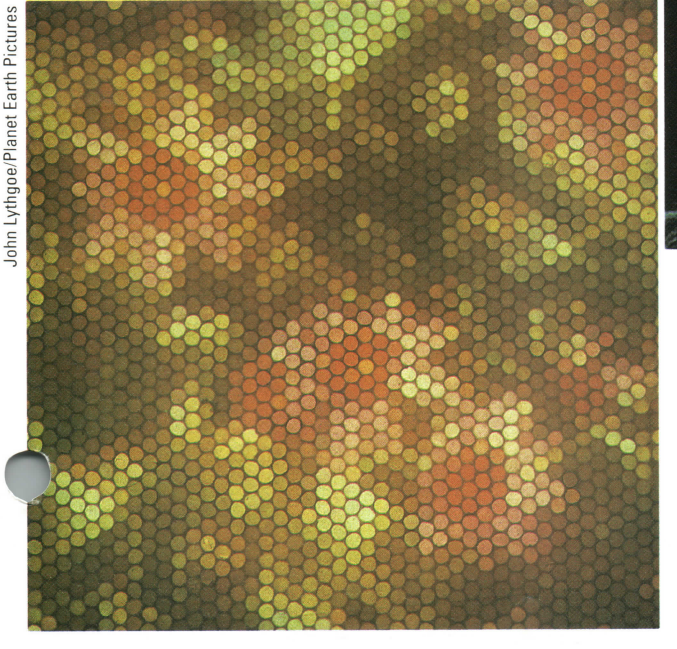
There are about 125 million tiny light sensitive cells on the retina. Many of these cells can detect the energy carried by just a photon or two of light. There are two types of light sensitive cell: rod cells and cone cells.

Rod cells are very sensitive to dim light and give us black and white vision, while cone cells respond to brighter light and give us our colour vision. Go outside on a dark night and things look like a black and white film on TV – this is because only the rod cells are sensitive enough to pick up the low light levels around.

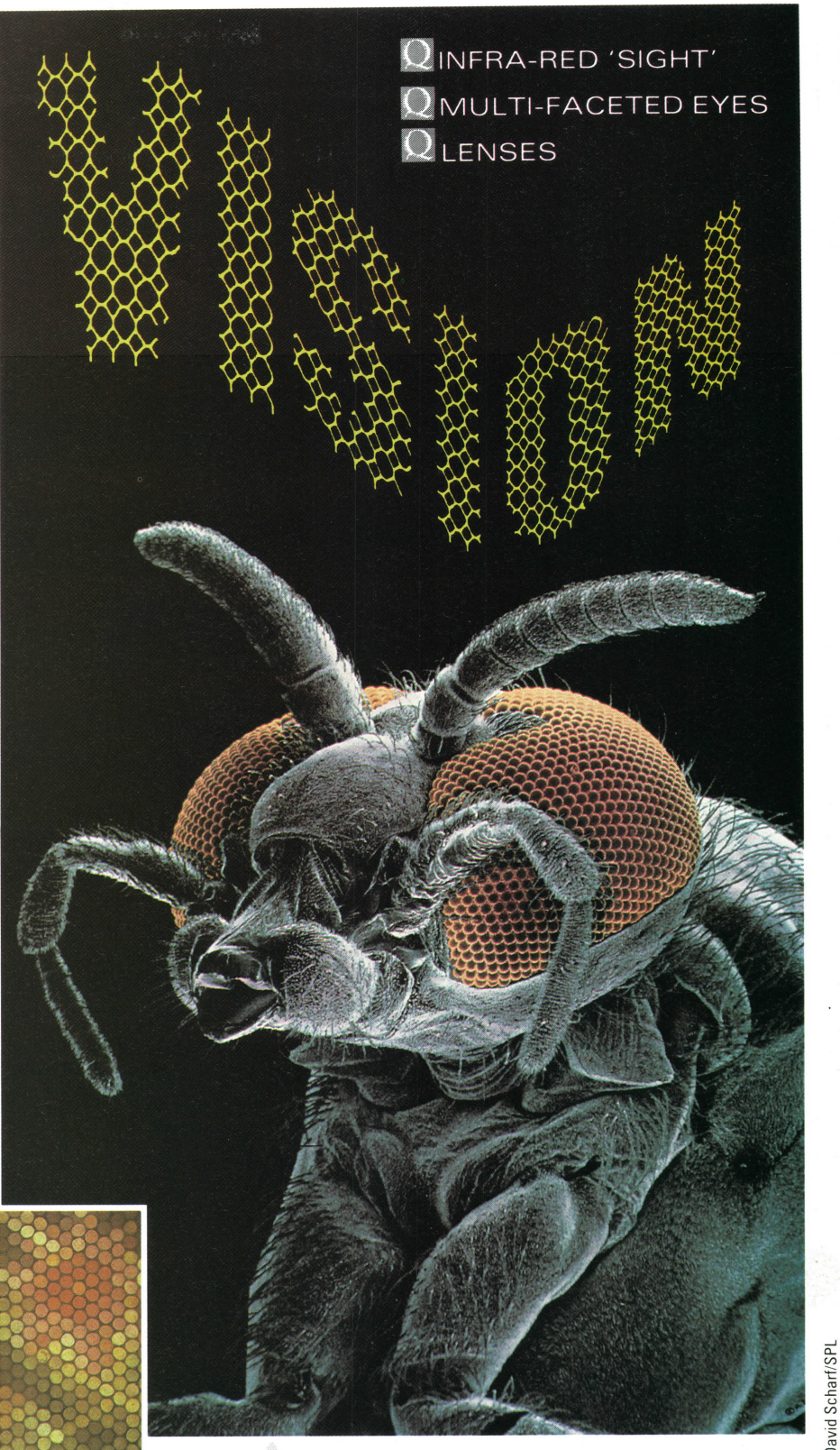
Rod cells are spread relatively evenly over the retina while cone cells are concentrated in an area called the fovea. This is a tiny area about 1 mm across where our attention is focused. You have to bring an object into focus at the fovea to see it best.

When you read a page you only really properly see a word or so at a time. Look at a single word on this page without moving your eyes for a few seconds and you'll see how hard it is to make out any others very far away from it. Most colour perception also takes place at the fovea.

Both rod and cone cells contain pigments that respond to the energy in light by generating a minute electric current. Rod cells are sensitive to light across the visible spectrum, while scientists think that there are different cone cells sensi-



John Lythgoe/Planet Earth Pictures



David Scharf/SPL

***Many eyes** make light work. The many faceted eye of insects (such as the fly's, above) consists of several hexagonal units. Each contains a lens that reflects light on to light sensitive cells. The fly's eye view of flowers would appear in a hexagonal grid (left).*

An eagle's eye *view is wide – and detailed. An indented area on the retina magnifies the centre area, allowing the eagle to distinguish prey that is camouflaged.*

John Downer

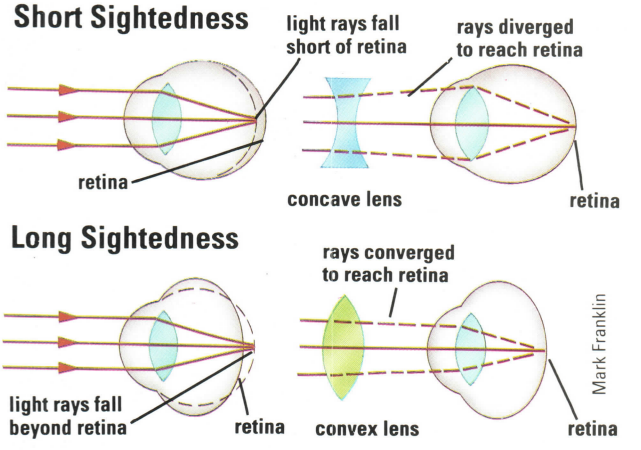
tive to each of the three primary colours: red, green and blue. Effectively, the complete range of colours we see can be made by mixing lights of these three colours.

The tiny current thus generated makes both rod and cone cells send a pulse down a nerve towards the brain. Each cell is capable of sending approximately 1,000 such pulses a second. Even a fantastic supercomputer like the brain would have trouble making sense of 125 million cells each sending it signals 1,000 times a second.

Fortunately, the cells do not fire constantly at this rate and, on the way to the brain and in the brain itself, the signals are interpreted by other cells. The first stage of this transmission is at the retina where cells, called bipolar cells, collect pulses from groups of cells before sending information down the optic nerve towards the brain. There are about 800,000 nerve fibres leaving each eye.

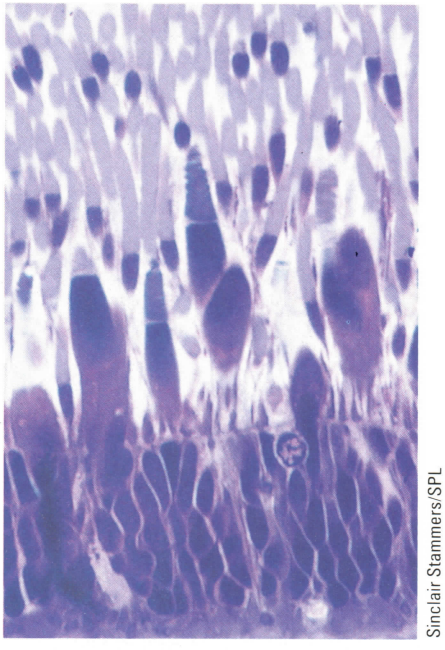
The process through which we understand the messages that reach our brain is not fully understood. It is known that there are some cells that respond to movements and shapes, and others that compare input over time while looking for changes.

The amount of information is whittled down as it travels further through the paths in the brain. Cells take input from groups of other cells via the nerve fibres. Groups of these, in turn, feed information to fewer cells as the brain makes constant comparisons and interpretations while responding to the input. Eventually, information about the outside world is perceived and becomes part of the constant flow of impressions, feelings and thoughts that make up our conscious minds. So much so, in fact, that we are rarely conscious of seeing at all.



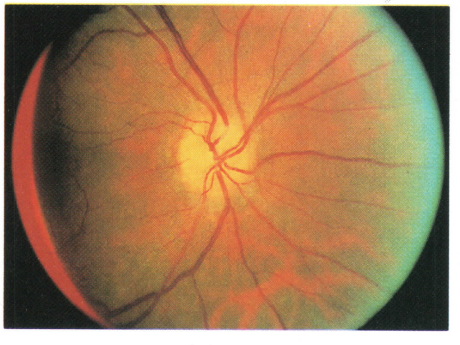
Short sightedness *can be corrected with concave lenses; long sightedness with convex lenses.*

Mark Franklin



Light sensitive cells *on the retina show up as rods (thin) and cones (purple bulbs). Below them lies a dense pigment layer.*

Sinclair Stammers/SPL



Alexander Tsiaras/SPL

The retina, *the innermost coat of the eye, is an extension of the optic nerve and consists mainly or nervous tissue. Veins and arteries leave and enter via the optic disc (the yellow area).*

Animal eyes vary greatly in appearance, structure and in how much fine detail they can see. But the essential mechanism of sight – electromagnetic energy hitting a light sensitive cell, causing it to fire and send a signal to the nervous system or brain – is similar to the human experience of sight.

However, eyes in different creatures are very diverse. They range from the human eye – with colour vision and great sharpness – to the light sensitive cells on the surface of an earthworm's head, where there is no lens as such – just a patch of cells that tell the creature where light is coming from.

Insects' eyes

Vertebrates have eyes with lenses that focus images on to their light sensitive cells just as in human eyes. But insects have eyes made up of many thousands of lenses, each of which aims light at only a few light sensitive cells. Such eyes are called compound eyes, but they are much less acute than eyes with single lenses. The bee has a compound eye with 15,000 of these lenses or facets. However, bees can detect movement in front of them,

Paul Raymonde

Gotcha! *The snake uses small, heat-sensitive pads on its face to locate its prey. These can 'see' infra-red radiation from its victim's body heat (inset right) even in the dark.*

John Downer

C B Frith/Bruce Coleman Ltd

Shifty eyes. *Newly hatched flat fish are born with eyes on either side of their face. As they get older, they take to the bottom of the sea bed and one eye migrates to join the other!*

Bill Wales/Planet Earth Pictures

as the areas of light and shade pass over different areas of the eye in turn.

Though most living creatures have eyes, this does not mean that they see the world as humans do. Light sensitive cells in the compound eye of the bee, for instance, are sensitive to a section of the electromagnetic spectrum that we do not perceive – the ultraviolet section. Thus a daisy looks blue to a bee, not yellow.

Some snakes have cells that are sensitive to electromagnetic radiation in the infra-red band (heat radiation). They can 'see' when there is no visible light by picking up the heat radiated by their potential dinners.

Not all creatures can perceive colours, however; humans and other primates, such as chimps, have really good colour vision, as do birds, fish, reptiles and insects, including bees and dragon flies. But cats, dogs and a great range of the larger mammals see the world only in shades of grey.

Amphibious creatures – those living in and out of water – have a problem: air and water bend (refract) light in different ways. This means that eyes that work in air won't necessarily work as well in water and vice versa – the image will not be focused on the retina.

To get round this, different creatures have different solutions. Penguins, who rely on acute vision underwater to catch fish, have flat-tish fronts to their eyes so that the differing amounts of refraction will not affect their vision. Certain water beetles have eyes split in two – the upper section is for above water; the lower, for under water.

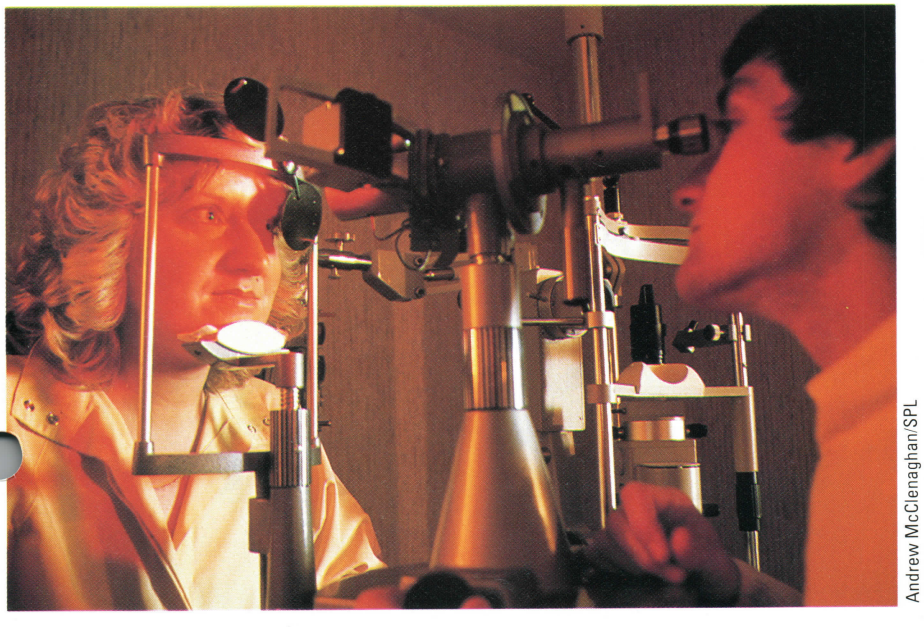
Some people have problems such as short and long sightedness. This is because the image is not focused properly on the retina.

Fortunately, both these problems can be corrected by wearing an appropriate glass or plastic lens in front of the eye, either as spectacles or contact lenses. Short sightedness is corrected by a diverging lens and long sightedness by a converging lens.

In another defect, astigmatism, the image is not focused uniformly (at one point) on the retina. This can also be rectified with an appropriate lens that corrects the distortion of the image. As people get older, they tend to become more long sighted. The muscles controlling the lens weaken with age, so they cannot squash the lens down to bring close objects into focus. The answer is converging lenses, which are worn for close work, such as reading.

When someone has short sight and needs lenses for close work, they can have bifocal lenses. In these, the lower part of the lens has a different focal length to the upper. Modern multifocal lenses, have a variable focal length over the bottom half so a hard line is not visible where the focal lengths diverge.

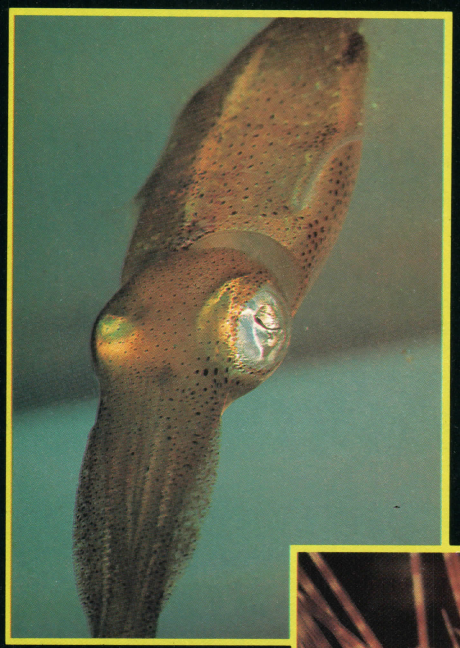
The shape of the eye *is measured by an optician using a kerometer to test for astigmatism or glaucoma.*



Andrew McClenaghan/SPL

THE OPTICAL WINDOW

It is not simply chance that we see the range of light wavelengths that we do. The Sun sends out electromagnetic radiation in a wide range of wavelengths, but most of these are absorbed by the Earth's atmosphere. The wavelengths visible to most surface dwelling creatures are the ones that are able to penetrate through the atmosphere. Astronomers call this range of visible wavelengths the 'optical window'.

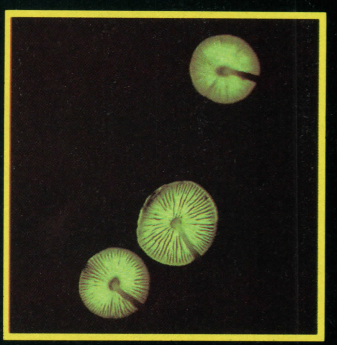


Jane Burton Bruce Coleman Ltd

In the depths *of the sea, where light is scarce, the pop-eyed squid sheds its own glow. This may be to attract a mate or scare away an enemy.*

Luminescent eyes *criss-cross a sea urchin to help it find food in the dark at the bottom of the sea where it lives. Without its own source of light, it would starve.*

Bioluminescence *is the light exhibited by some plants and animals when enzymes within them react with oxygen, as in the fungus below.*



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Larry Madin Planet Earth Pictures

Looking like an X-ray, *a jelly fish lights its own way in the darkness of the ocean depths. The disadvantage, of course, is that predators can see it, too.*

Jane Burton Bruce Coleman Ltd

A beacon *in the dark, the last few segments of a firefly light up to attract a mate. The colour, intensity and frequency of the glow can vary considerably.*

Ivan Polunin NHPA

Agence Nature NHPA

The viper fish *can adjust the lights (photophores) on its underbelly to match the light from the surface above. This makes it invisible from below.*

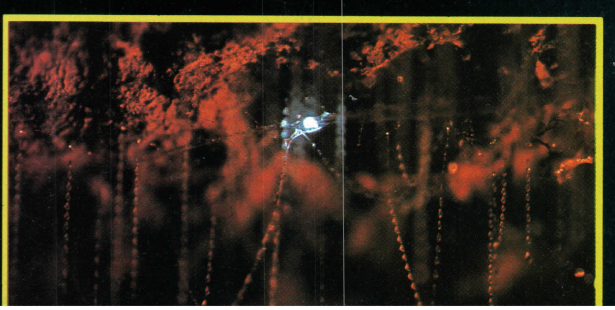
Kim Taylor Bruce Coleman Ltd

Starkly silhouetted, *a ground beetle stands out against birchwood that is illuminated by the honey fungus covering it.*

G I Bernard NHPA

Iridescence *in a butterfly's wing is caused when some light waves are reflected from the surface and some are absorbed and then reflected from below the surface.*

Fireworks *are created in a cave as glow-worms flit about. Glow-worms are nocturnal beetles that are luminous as adults and, sometimes, as larvae. They can often synchronize their flashing when in a group.*



Frances Furlong Bruce Coleman Ltd

Phil Jude/SPL

OPTICAL ILLUSIONS

A mirage *of water around an oilfield in the desert is caused by hot air close to the ground bending the light.*

Peter Aprahamian/SPL

WITHOUT A DROP OF WATER left in his canteen, the intrepid explorer sees trees and water on the horizon – the promise of life. He stumbles on and on, until the heat and dehydration finally defeat him. What he was trying to reach was a mirage.

Mirages are just one type of illusion where we either see or perceive objects or images that are either not there or not what they seem.

If you stare long enough at a sheet of red paper, then look at a white sheet of paper, the white paper might take on a greenish tint. This happens because the eye and the brain get accustomed to the red paper and try to compensate for the red appearance of what they are looking at by boosting their receptivity to green light. So when you look at the white paper your eyes are more sensitive to the green content of the light reflected from it – giving it a green appearance.

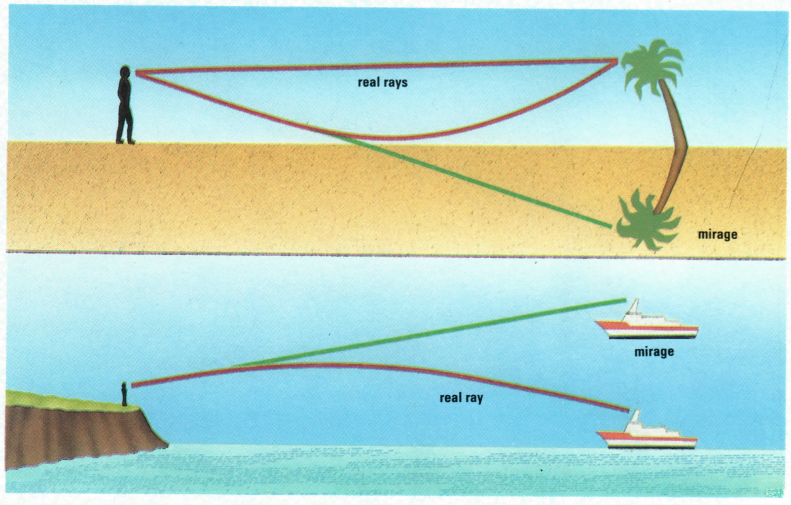
Similarly, if you look at colours in patterns, look at other patterns or plain surfaces, after-images and false colours can appear where none exist.

Movement illusions

If you stare at the water falling from a waterfall for long enough, then look away to a plain surface where there is no movement, such as grass, you can see what appears to be movement upwards on the plain surface. This is another example of the visual system getting used to one continual input, then when that input is removed the opposite appearing.

Some theories say that this phenomenon is due to fatigue. For example, the parts of the visual system that are receptive to downward movement become tired, but the sensors that are responsible for detecting upward movement do not. So when the movement stops, the reduced input from the fatigued downward sensors gives the appearance of upward motion.

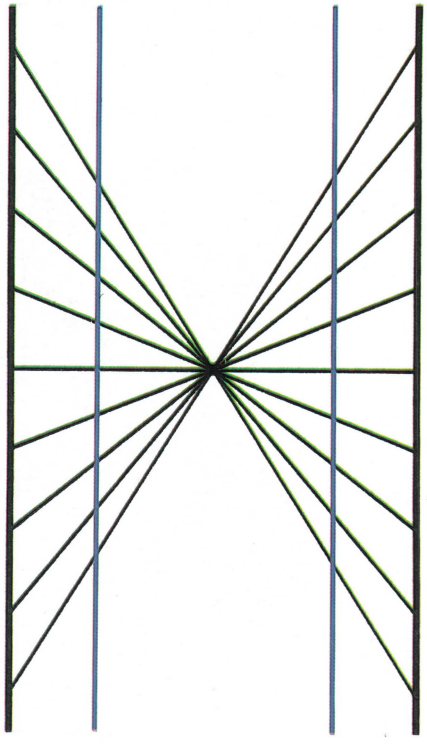
MIRAGE – THE ILLUSION THAT CAN KILL



Mark Franklin

When the ground is warmed by sunlight, the air close to the ground gets very hot. Hot air is less dense than cold air and denser air refracts (bends) light more than less-dense air – so the atmosphere close to the hot surface acts like a giant lens. This giant lens bends the light from a distant object – which could be many kilometres away from the observer – back to ground level, making it seem closer than it is.

A similar effect occurs when a tarmac road gets very hot. If you look along the road you can sometimes see a shimmering metallic image. This is simply light refracted by the air of different densities close to the hot surface of the road.



John Woolford

Pictures of impossible objects are another good example of optical illusions. In some paintings impossible things happen, such as people walking up endless staircases. These visual tricks are performed by the use of false perspective – the brain tries to make a three-dimensional image out of what is, in fact, just a series of lines on paper.

Other illusions can show straight lines bending (see above), perfect circles being distorted and lines and shapes of equal length or size appearing to be different. Normally visible objects can also be made to disappear.

Fooling the eye into seeing images in three dimensions is not too hard. One old-fashioned way of doing this is the stereoscope. This uses pairs of colour slides viewed through lenses – one is seen through the left eye piece, the other through the right.

The pairs of slides are taken by a camera with two lenses and two rolls of film. Its lenses are spaced the distance between your two eyes apart. When the slides are viewed simultaneously, they present the viewer with a pair of images just different enough to give three-dimensional appearance to the objects shown. The two views are what your two eyes would see if you were standing where the camera was.

The vertical blue lines *appear bent – but only because the brain expects a curved line on the end of an array of spokes.*

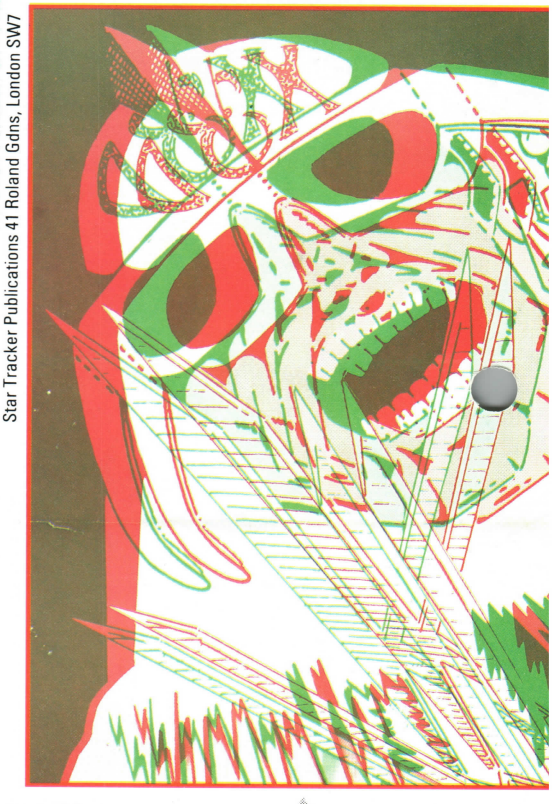
The Walt Disney Company

The illusion of 3-D *can be given by printing two slightly different images – one in red, one in green. Glasses with one red lens and one green lens (left) ensure that one eye sees only the red image and the other sees only the green.*

3-D movies *can be made in the same way. Each frame has two slightly different images, filmed by two cameras, mounted side by side, whose lenses are the same distance apart as your eyes.*

On the Moon

The American astronauts walking on the Moon in the late 1960s and early 1970s had a problem judging distances. The distance of far away objects is not judged by the eyes focusing or swivelling slightly so that they are both pointing at the object you are looking at – it is other clues that tell how far they are away. On Earth, one of the most important of these clues is the fact that air gets less clear further away.



Star Tracker Publications 41 Roland Gdns, London SW7

THE TROPICAL FOREST

EVOLVING JUNGLE | FOREST LAYERS | DEFORESTATION

IN THE JUNGLE, DEATH threatens at every step. The air is hot and damp, huge trees soar 30 metres or more into the air, venomous snakes curl around the branches, monkeys chatter and parrots screech.

In the dense undergrowth all manner of fierce or poisonous animals hide, ready to bite or attack with claws and teeth. However, popular myth has clouded reality, for not all jungles are the same. They vary greatly in different parts of the world. Scientists now use more accurate terms, such as 'tropical rain forest' or 'subtropical montane cloud forest', to describe what most people call a 'jungle'.

Tropical rain forests are in the tropics, of course. This means they grow between the Tropics of Cancer and Capricorn, in a narrow band around the Earth on either side of the equator. The climate is warm throughout the year, with average temperatures of about 20–28°C.

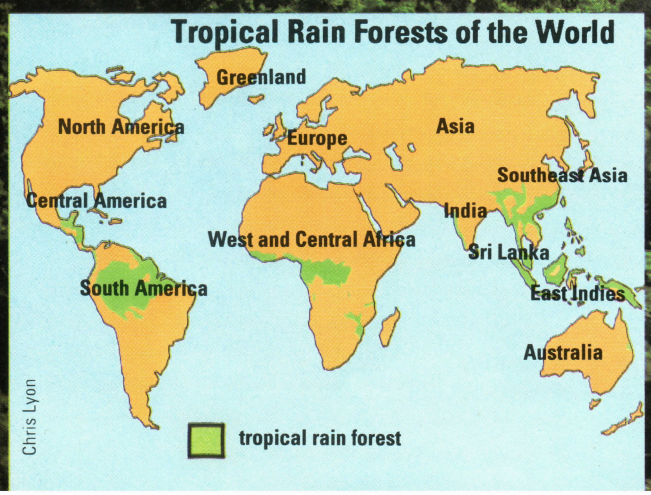
True tropical rain forests grow only in the lowlands, not high up on mountains. This is because as you

Victor Englebert/Survival International

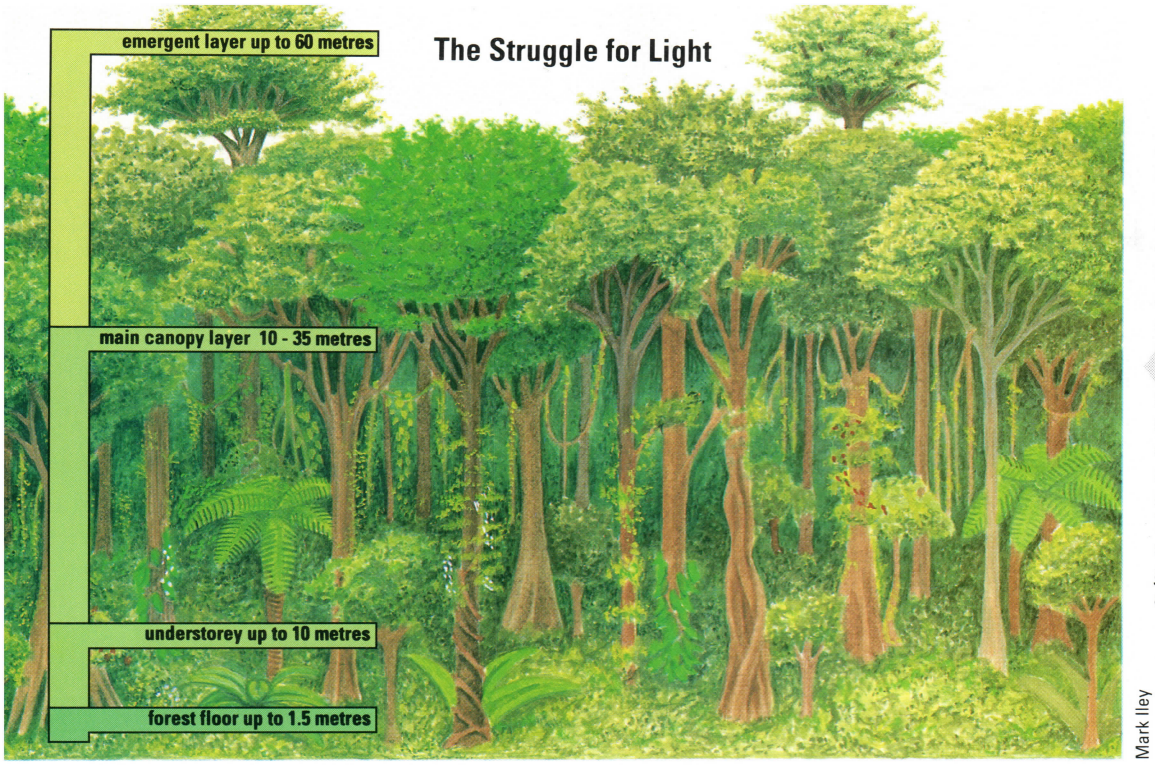
Partridge Films Ltd

The Yanomami Indians *of the Brazilian rain forest use hunting skills passed down through generations. Their longbows are made of palm wood with strings from the bark of coca ash trees: the arrows are sharpened bamboo canes. A typical quarry is the white-lipped peccary, a kind of wild pig.*

The forest canopy *and dense understorey of the jungle of Brunei in the East Indies provides shelter and protection for many species.*



Chris Lyon



The Struggle for Light

Jungle vegetation *struggling for light forms four distinct layers. The forest floor – a thin layer of decaying leaves and animal remains – eventually becomes soil. Shrubs, mosses and small trees form the understorey. Above these is the forest canopy – the branches and leaves of the tall evergreen trees. Towering above everything are the giant trees of the emergent layer.*

Mark Iley

travel up a mountain, the temperature falls and it is not warm enough for a true tropical forest to grow – even in a tropical region.

The third main feature of tropical rain forests is rain. The rain falls throughout the year rather than in one wet season. In general, rain forests grow where the rainfall is more than 1,800 mm each year. A tropical storm can pour down 200 mm of rain in one hour.

M P L Fogden/Bruce Coleman Ltd

Bromeliads *are distant relatives of the pineapple. Their leaves form ponds used by a host of little creatures.*

Jungle birth

These huge amounts of water are soaked up by the forest trees and other plants. They also 'breathe' water vapour from their leaves back into the atmosphere, which forms more clouds – and so more rain.

Tropical rain forests have been on Earth for more than 75 million years. At that time, two thirds of the giant 'supercontinent' called Gondwanaland was covered by forests. Thousands upon thousands of plants and animals, including the great dinosaurs, evolved to suit the conditions of the time.

Slowly, over millions of years, Gondwanaland split up and the pieces drifted apart to form the continents as we know them today. The world's climate changed, becoming colder and drier. The lush tropical forests gradually became smaller and separated into distinct 'pockets'. Animals and plants evolved to fit conditions in their own locality. But then the climate warmed up again and became wetter, so that the pockets of forest gradually grew back together. These changes probably happened several times, and over time the forest life became richer and more varied.

The strangling fig *tree sends roots down the trunk of its host. As they thicken the host tree dies and rots.*

Jeff Foote/Bruce Coleman Ltd

Vast numbers of animals live in every layer of the jungle. They all depend on each other and on the vegetation that supports them – and they are not found anywhere else.

When a large patch of tropical rain forest is cut down, it may take up to 400 years to grow again. At first the quick-growing 'pioneer' plants cover the clearing. Then in about 10 or 20 years various small trees and shrubs grow. The giant trees grow much more slowly, struggling through the low vegetation to reform the canopy. Then vines and creepers re-establish themselves and the thousands of animals that can only live in the rain forest return.

Sadly, such enormous areas of rain forest are now being cut down that there is little chance that they will be able to heal themselves.

Just amazing!

NO VACANCIES!

A HUNDRED TIMES MORE LIFE FORMS CROWD INTO A TYPICAL 4 SQ KM PATCH OF TROPICAL RAIN FOREST THAN WOULD BE FOUND IN A COMPARABLE PATCH OF EUROPEAN FOREST.

Paul Raymonde

MEAT EATERS PARASITES LETHAL TRAPS

The giant leaves *of the Amazonian water-lily are 1.5 metres across and can support the weight of a child.*

M W F Tweedie/NHPA

PLANT POWER

Hutchison Library

The biggest flower *in the world – the rafflesia – weighs 6 kg and is 1 metre across. Its putrid smell of rotting flesh attracts flies.*

PLANTS SUPPORT LIFE ON Earth. They capture the Sun's energy and use it to power chemical reactions in which simple chemicals are built up into living tissue.

All animals depend on plants. They either eat them or they eat another animal that has eaten a plant. Nowhere are plants more numerous than in the jungle.

Staying upright

Forest trees need to be tall in order to receive the energy-giving sunshine from above. They also need nutrients from the soil beneath them – but rain forest soil is very shallow, since leaves and other debris rot away so quickly in the warm, damp conditions. Therefore forest trees do not have long, deep roots and staying upright can be a problem.

Some trees, such as the silk cotton tree and giant oje fig tree, have solved the problem by having buttresses – large flanges or wedges that stick out from the lower trunk, spreading sideways to make the base of the tree broader.

In especially poor soils, some plants get the nutrients they need by eating meat. They trap small animals by all sorts of ingenious snares. Pitcher plants trap and digest insects in their deep, pot-shaped 'pitchers'. Pitcher plants that grow in the wet jungles of Borneo root in the forest floor and send shoots 15 metres up into the trees, or germinate in crevices in the bark of trees high in the canopy.

The 'pitcher' is made from the shaped end of a leaf, with a narrow neck and a lid. Inside, it is about one-third full of a lethal acidic liquid that contains a special chemical, the enzyme trypsin, which dissolves the protein that makes up the tissues of an insect. There are many kinds of pitcher – some are up to 30 cm long and hold 1 litre of fluid.

Paul Claxton/Orpix

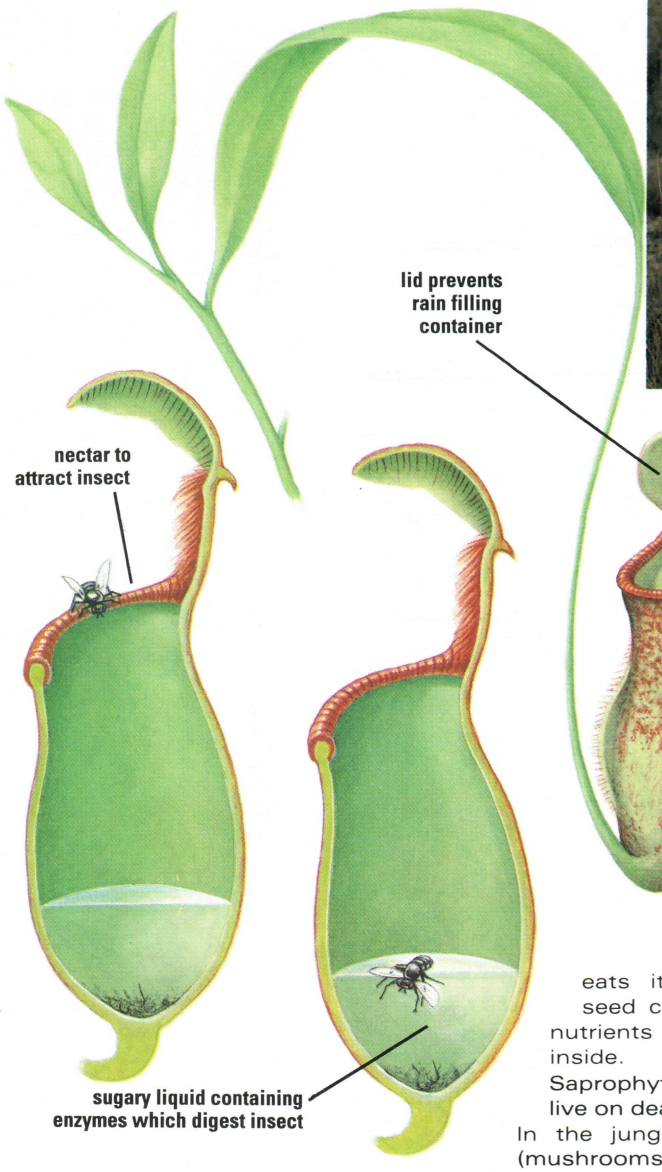
The aerial roots *of an epiphytic orchid are designed to hang from tree-tops and absorb moisture from the humid air.*

Into the light

Epiphytes are plants that grow high up in the branches of trees to overcome the lack of light on the forest floor. They do not take nourishment from the tree, as a parasite would, but use it only for support. By doing this, however, they give up the usual method of absorbing nutrients and moisture from the soil through their roots.

The orchid family includes a number of typical epiphytes. This is one of the largest families of flowering plants – there are over 30,000 species – and most of them grow in warm, humid tropical regions. Many

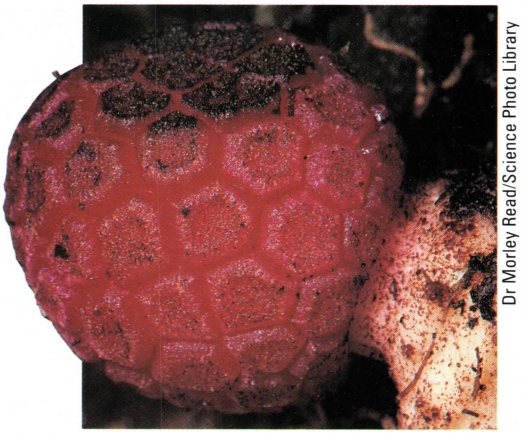
How a pitcher plant feeds



Claude Nuridsany & Marie Peronnou/SPL Mark Illey

Carnivorous *pitcher plants attract insects with their nectar and bright colours. Unlucky insects drown in acidic liquid in the urn-like traps and are then digested.*

This parasitic *flowering plant from Ecuador takes all its nourishment from the roots of forest trees.*



Dr Morley Read/Science Photo Library

have aerial roots, which hang down in mid-air from the tree tops and absorb moisture from the humid air. Others have roots that cling to the bark of the tree in a dense tangle to trap bits and pieces falling from the canopy above.

Orchid seeds are so tiny that three million would weigh just 1 gm. They spread on the breeze, but they cannot germinate and start to grow without a special fungus that eats its way into the seed case and provides nutrients for the tiny plant inside.

Saprophytes are plants that live on dead organic matter. In the jungle, various fungi (mushrooms, toadstools and the like) are the main saprophytes. They are a vital link in the cycle of nutrients, helping to break down dead plant and animal tissue so that the nutrients go back into the soil, ready to be used again by the trees.

Unlike saprophytes, which eat dead things, parasitic plants get their nourishment from a living host. The rafflesia flower is a parasite of vine roots. It receives no sunlight and must, therefore, get its energy from another source. Its roots eat into and suck nutrients from the roots of cissus vines. The only part that shows above the ground is the flower.

Living together

When two things live together in a mutually beneficial partnership, this is known as a symbiotic relationship. Symbiotic associations are common in the jungle. For example, certain fig trees live symbiotically with a tiny wasp. These trees have three sorts of flower – a male, female and gallflower. The gallflower provides a safe home for the gallwasp larva. The adult gallwasp carries the pollen from the male flower to the female one.

A lichen is a partnership between a fungus, the main body, and an alga, which forms a layer near the surface of the fungus. Together they grow more slowly and live longer than they would apart. In jungles lichens grow on tree trunks, absorbing moisture and nutrients from rainwater.

Tony Morrison/South American Pictures

Support is essential *for rain forest trees that grow up to 30 metres tall. They use their own roots to keep them upright.*

Just amazing!

SEARCH LIGHT

JUST TWO PER CENT OF LIGHT FROM THE SUN FILTERS THROUGH TO THE FOREST FLOOR – THE DENSELY PACKED TALL TREES PREVENT ANY MORE GETTING THROUGH.

Paul Raymonde

- RAVENOUS ANTS
- GIANT SNAKES
- KILLER SPIDERS

Frieder Sauer/Bruce Coleman Ltd

Michael Freeman/Bruce Coleman Ltd

Survival *is the name of the game in the jungle. Small birds fall prey to giant spiders, while tiny plants flourish on the tresses of a sloth (above).*

WILD LIFE

LIFE TEEMS IN AND AROUND the trees of a rain forest. Different types of mammals, birds, reptiles and amphibians, and vast numbers of insects live closely at every layer in the forest, dependent on each other and on the trees around them.

Animals such as monkeys, birds, butterflies and flies, that live in the top layer – the jungle canopy – lead noisy and colourful lives. Lower down in the branches are snakes, frogs, insects, slugs and snails that creep among the humid trailing vines.

On the forest floor, insects, worms, millipedes and other small creatures eat the debris that rains from above. In every layer, any animal that is not wary enough can suddenly find itself becoming a meal for someone else.

Swinging about

Most jungle monkeys live in groups, howling and screeching to each other as they search for food, or warn members of their troop about enemies such as kites, eagles and snakes. Their long arms, strong hands and gripping thumbs enable them to swing from branch to branch at great speed through the treetops.

Monkeys see in colour so that they can spot the bright, ripe fruits they feed on from far away. With two forward-pointing eyes, they can judge distances accurately as they jump from tree to tree. Good eyesight also helps in seeing whether a branch is old, rotten and about to crack – which can mean a fall to the ground 50 metres below, and almost certain death.

High in the canopies of South American rain forests live the sloths. These curious creatures move slowly and deliberately through the trees, hanging upside down by their long, curved claws. A sloth is almost impossible to see

YELLOW SPELLS DANGER

How can apparently defenceless creatures like these frogs sit calmly in full view of any passing jungle hunters? The answer is in their colouring. For the vivid yellow and black of the Arrow-Poison Frog of Venezuela is a potent warning to potential predators: their harmless-looking skin actually secretes a deadly poison. Yellow (and especially yellow and black) is often used in the animal kingdom as an effective warning signal. Together the two colours create a distinctive, easily-recognized pattern that warns other animals – and humans – to keep their distance, or else suffer the deadly consequences.

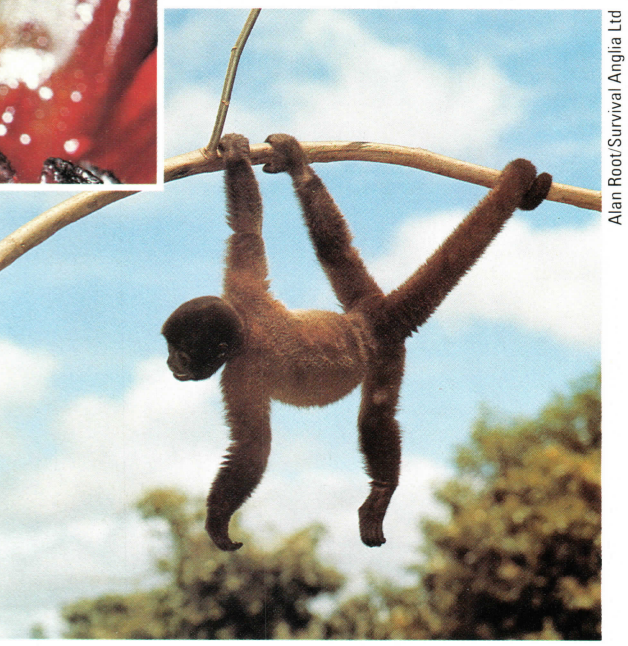
Jeff Frost/Survival Anglia Ltd

Dr Morley Read/Science Photo Library

Nothing is wasted *in the jungle. Two wasps gorge themselves on the blood of a peccary (a kind of wild pig).*

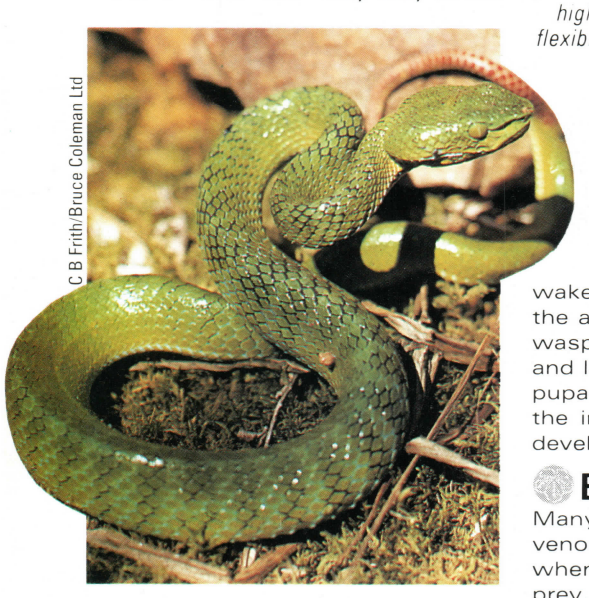
among the leaves, because its hairs are coloured green by algae (tiny plants) growing on them. The hair hangs downwards so that the rain runs off it easily.

Sloths use very little energy, so they do not need much food. Each sloth prefers the leaves of a certain plant, which means that the sloths in one area do not all try to eat the same food. The meal is digested in a huge stomach, which contains bacteria that dissolve the tough plant material. One meal may stay in the stomach for up to a month. A sloth only urinates and defecates about once each week, in the same place – usually at the bottom of a tree.



Alan Root/Survival Anglia Ltd

A prehensile *(gripping) tail acts as an extra limb for the common woolly monkey, which lives in family groups high in the trees. The flexible tip also bears a fingerprint.*



C B Frith/Bruce Coleman Ltd

The Asian green pit viper *blends deceptively into the foliage. Explorers have told of pushing aside harmless branches only to find the poisonous snake underneath.*

An army of ants

Army ants live in vast colonies on the jungle floor. The colonies are so big that they rapidly devour all the food in an area, so they must soon move on. When the colony, or army, is on the march, any animal in its path must either get out of the way – or be eaten alive.

However, many creatures need army ants for their survival. Birds, butterflies and wasps follow the raiding parties and clean up after the ants, feeding on the dead or dying plants and animals left in their wake. Some parasitic wasps use the ant larvae as living larders. The wasp manages to get into the nest and lay its eggs in the ant larvae or pupae. The ants are then eaten from the inside by the tiny wasp grubs developing within.

Beware poisons!

Many jungle creatures rely on venom, either to defend themselves when attacked, or to inject into their prey, to paralyse or kill it. The venom of some snakes is a neurotoxin – it prevents the victim's nerves from working properly so that it cannot make any movements at all, sometimes not even breathe.

One example is the Gaboon viper from Africa – the largest of all vipers. Its body is 2 metres long and up to 15 cm thick. The vivid pattern on its back blends in with the leaves on the forest floor, providing the perfect camouflage as it waits to ambush frogs, birds and mice. This species also has the longest fangs of any snake: up to 50 mm in length.

Tropical bird-eating spiders hunt among the jungle branches for nestlings and small birds. Their bite can easily kill a humming-bird, but it is not much worse than a bee sting to humans. If you try to handle one of these spiders, however, its hairs break off and cause terrible itching, swelling and skin irritation.

The largest bird-eating spiders are more than 25 cm across. They have various names – tarantulas in America and baboon spiders in Africa. They also eat small insects, frogs, snakes and other spiders.

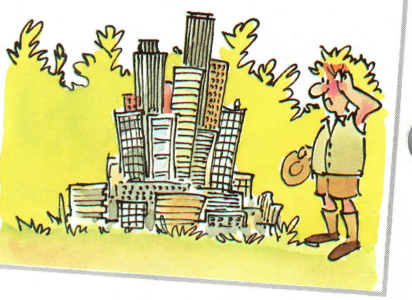
Another fearsome hunter of the rain forest is the giant Malayan centipede. This grows up to 20 cm long and its movements are almost too quick to follow with the eye as it dashes through the leaves. Its bite has been known to kill a human.

Millipedes are close relatives of centipedes, although they eat rotting leaves rather than hunt for prey. Their venom is used in defence. Some rain forest millipedes can spray a poisonous fluid up to one metre.

Just amazing!

MASSED RANKS

A SINGLE COLONY OF ARMY ANTS MAY CONSIST OF MORE THAN 20 MILLION INDIVIDUALS – MORE ANTS THAN ALL THE INHABITANTS OF MEXICO CITY, THE WORLD'S MOST POPULOUS CITY.



Paul Raymonde